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# A REVIEW OF PARAMETRIC OSCILLATORS AND MIXERS AND AN EVALUATION OF MATERIALS FOR 2 - 6 MICROMETER APPLICATIONS

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A tunable source of narrow line radiation in the 2-6 μm band and, to a lesser extent, the 8-12 μm band would be useful in several military applications. Only recently have nonlinear optical materials become available to permit construction of optical parametric oscillators (OPO's) and mixers operating at these wavelengths. In this report, a review of the progress in wavelength coverage and output of OPO's and mixers is given, the theoretical performance of eleven nonlinear materials is discuss in detail, and as an example, the

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materials are compared for use in operating a singly resonant OPO in the 3-6 μm band. For this application, the outstanding materials are HgS pumped at 1.06 μm and $ZnGeP_2$ pumped at 2.1 μm. Refractive index data on the nonlinear materials and details of the FORTRAN computer program used in the calculations are included in the Appendices.

## FOREWORD

This report covers work performed in the period 1 January 1974 through 15 May 1974. The work was a joint effort of AFAL, ARL, and AFML. AFAL participation was carried out under Project, Task and Work Unit number 2001-01-16, with E. R. Nichols as Project Scientist. ARL participation was under Project, Task and Work Unit number 7073-02-11, with J. C. Corbin, Jr. as Project Scientist. AFML participation took place under Project, Task and Work Unit number 7371-01-01, with V. L. Donlan as Project Scientist. The capable assistance of Mrs. Margie Smith who typed the greatest part of this report is greatly appreciated.

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## INTRODUCTION

There are spectral regions in the infrared that are not occluded by atmospheric absorption[1]. The coincidence of good detectors and atmospheric transparency in the 2-6 μm and the 8-12 μm bands makes these spectral regions of special interest. Military applications in the 2-6 μm band and, to a lesser extent, the 8-12 μm band have been discussed elsewhere[2]. Prior to 1970, tunable sources had not been developed to provide continuous coverage of these bands, although discrete line lasers were available at fixed wavelengths throughout the bands. Since then, the availability of new nonlinear optical materials with wide band infrared transparency has made possible the construction of optical parametric oscillator (OPO) and mixer devices that operate continuously over the 2-6 μm and 8-12 μm bands. (Although tunable semiconductor sources such as the lead salt diodes and spin flip Raman lasers have recently been developed, we do not consider such devices in this report.)

In Section II, we discuss parametric oscillators. A review of the chronological development of wavelength coverage and a discussion of power output and efficiency vs wavelength are given. In Section III, we review recent work on tunable mixers. In Section IV, we calculate and discuss the theoretical performance of 11 nonlinear optical materials. In Section V we show, as an example, how the theoretical performance data can be used in selecting a pump wavelength and a nonlinear optical material for a singly resonant OPO operating in the 3-6 μm band. In the Appendices we include the refractive index data and Sellmeier equations for each nonlinear material and present the details of the computer program used for the calculations.

## SECTION II

## PARAMETRIC OSCILLATORS

A parametric oscillator generates two waves, a signal and an idler, from noise in a nonlinear crystal when properly excited by a laser pump beam. The energy and momentum conservation requirements on the pump, signal, and idler beams are:

$$\omega_p = \omega_s + \omega_i \qquad \text{Energy Conservation} \qquad (1)$$

$$\underline{k}_p = \underline{k}_s + \underline{k}_i \qquad \text{Momentum Conservation} \qquad (2)$$

The theoretical maximum efficiency of the process for generating signal energy is $\omega_s/\omega_p$ and for idler energy is $\omega_i/\omega_p$ (Figure 1). For the degenerate case, i.e. $\omega_i = \omega_s = \omega_p/2$, 100% conversion is possible to a single line. In practice, 67% conversion has been obtained in a degenerate oscillator[3] and 100% conversion has been reported in the case of degenerate upconversion where the frequency of the pump is doubled.[4] Detailed discussions of parametric oscillators are contained in References 5 and 6.

The chronological progress in spectral coverage for nonlinear devices is shown in Figure 2 for the visible and infrared region. The numbers in Figure 2 correspond to the reference numbers given in Table I and in the list of references at the end of this report. $LiNbO_3$ is the most commonly exploited material and has been used from the green to 3.7 μm where it is limited by absorption. The materials used for parametric oscillators must be transparent or low loss at the pump wavelength as well as the signal and idler; they must also have adequate optical quality to allow an oscillator cavity to be formed. Pumping $LiNbO_3$[19] with different visible wavelengths

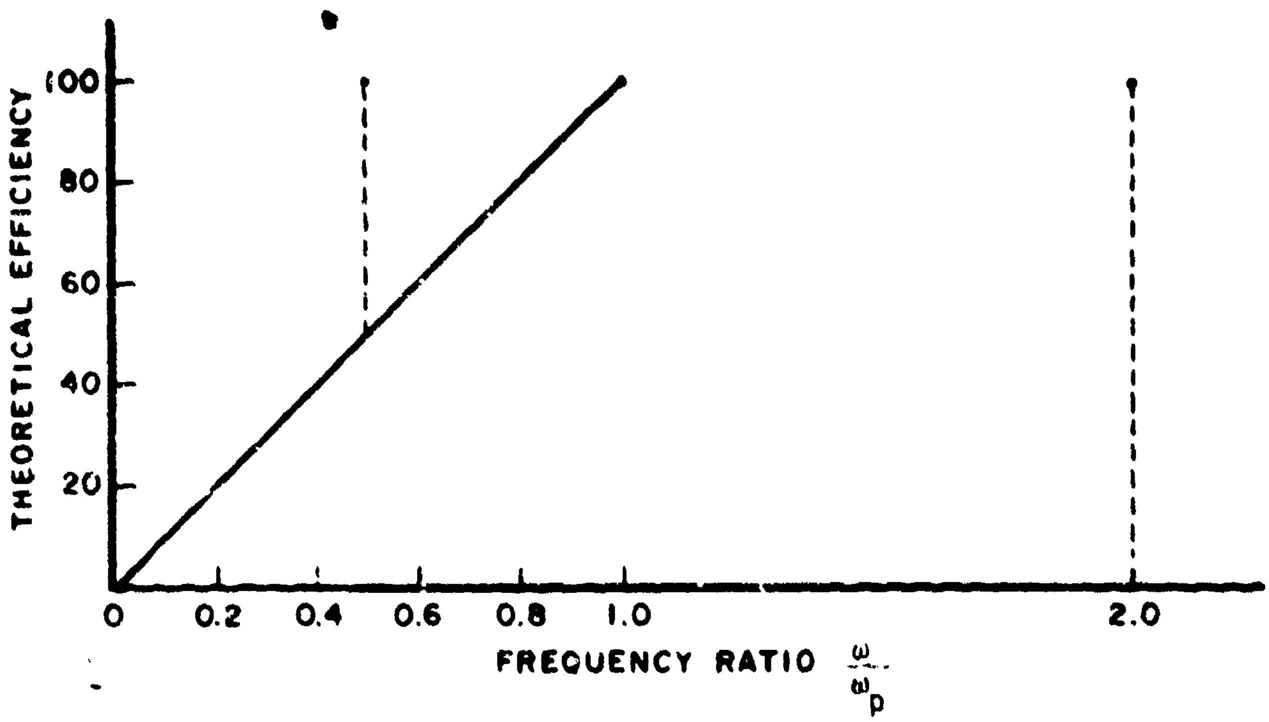


Figure 1. Theoretical Conversion Efficiency as a Function of the Ratio of the Generated Frequency to the Pump Frequency

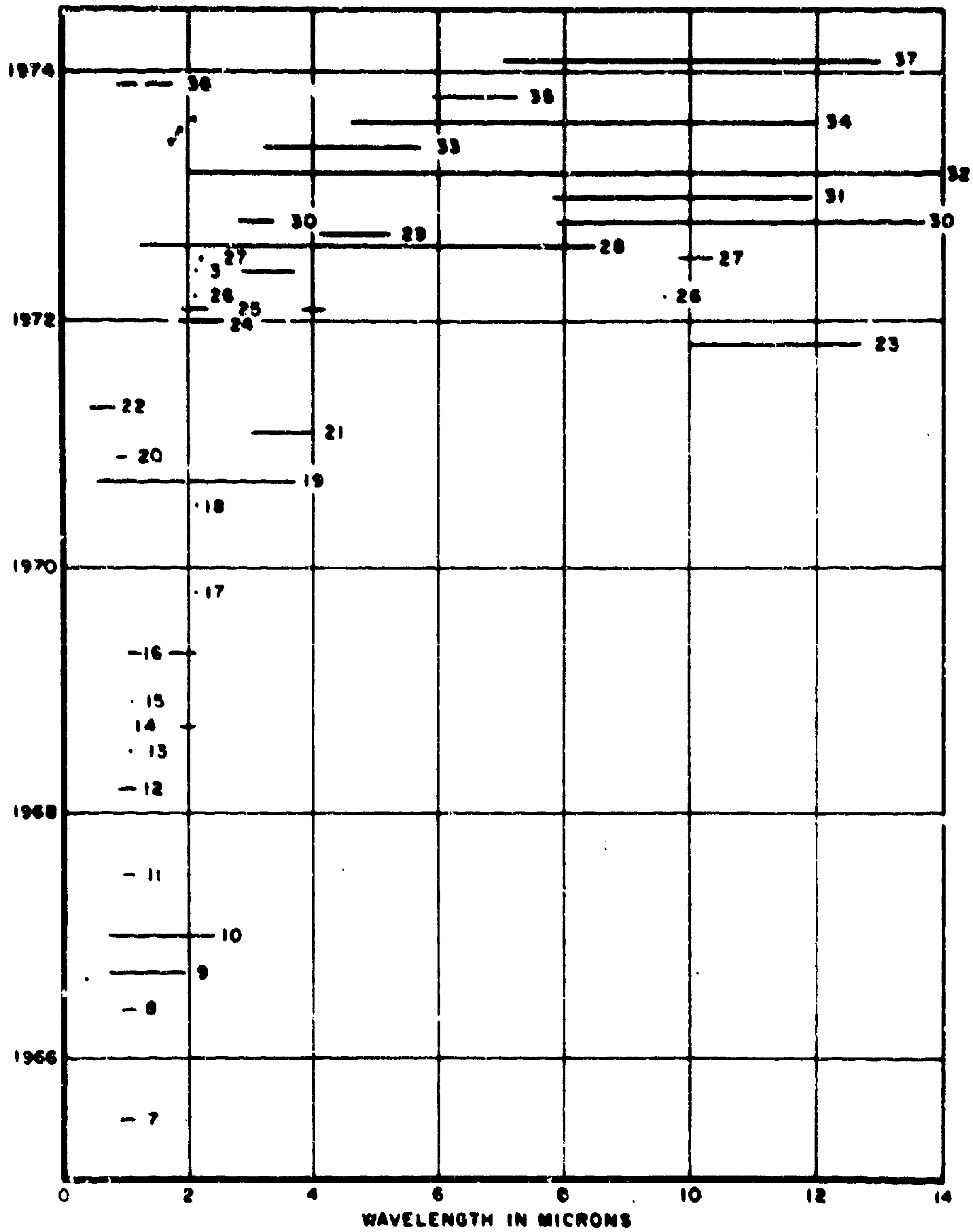


Figure 2. Chronological Development of Spectral Coverage

TABLE I. NONLINEAR EXPERIMENTS

| REF. | PUMP LASER | $\lambda_p$ (µm) | PUMP POWER OR ENERGY | TUNING TECHNIQUE | PUMP PULSE LENGTH (ns) | NONLINEAR MATERIAL | CAVITY S - SRO D - DRO M - MIXER | OUTPUT POWER OR ENERGY | OUTPUT PULSE LENGTH (ns) | REPETITION RATE | WAVELENGTH COVERED (µm) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Nd:CaWO$_4$ doubled in LiNbO$_3$ | 0.529 | 6.7 kW | Temperature | | LiNbO$_3$ | D | 15W | 15-40 | | 0.97-1.15 | |
| 8 | Nd:glass doubled in KDP | 0.530 | | Angle | 25 | KDP | D | 5kW | | | 0.9575-1.1775 | |
| 9 | Nd:CaWO$_4$Nd glass doubled | 0.530 | $10^5$W | Temperature | | LiNbO$_3$ | D | $10^3$W | | | 0.7300-1.930 | 1% Peak Power Conversion |
| 10 | Nd:glass doubled | 0.530 | $5\times10^4$W | Angle | | LiNbO$_3$ | D | 50W | | | 0.684-2.355 | 0.1% Peak Power Conversion |
| 11 | Ruby | 0.6943 | $3\times10^6$W | Electro-Optical and Angle | 40 | LiNbO$_3$ | D | $38\times10^{-3}$W | | | 1 - 1.08 | 1% Peak Power Conversion |
| 12 | Nd:YAG doubled in Ba$_2$NaNb$_5$O$_{15}$ | 0.532 | 300mW | Temperature | CW | Ba$_2$NaNb$_5$O$_{15}$ | D | 1.5mW each direction | CW | | 0.98-1.06 | 1% Avg. Power Conversion |
| 13 | Ruby | 0.6943 | 270kW | Fixed | 20 | LiNbO$_3$ | D | 60kW | 20 | | 1.04 + 2.08 | 76% Pump Depletion 22% Peak Power Conversion |
| | Ruby | 0.6943 | 630kW | Fixed | 20 | LiNbO$_3$ | S | 41kW | ~10 | | 1.04 | 6% Peak Power Conversion |
| 14 | Argon | 0.5145 | 1.148W | Temperature | CW | LiNbO$_3$ | D | 1.4mW | CW | | 0.68-0.705 2.11-1.90 | |
| 15 | Ruby | 0.6943 | 900kW | Fixed | 10 | LiNbO$_3$ | S | 250kW | 2 | | 1.06 | 28% Peak Signal Power Conversion |
| 16 | Ruby | 0.6943 | 750kW | Angle and Temperature | ~30 | LiNbO$_3$ | S | 340kW | 10 | | 1.64-2.05 1.20-1.05 | 25-45% Energy Depletion 45% Peak Power Conversion |
| 17 | Nd:YAG | 1.06 | 200mW | Temperature | 200 | LiNbO$_3$ | D | 170W Peak 17 mW Avg | 100 | 1-5kHz | 2.13 | 8.5% Avg. Power Conversion |
| 18 | Nd:YAG | 1.06 | | Temperature | 200 | Ag$_3$AsS$_3$ | D | | 100 | 2 kHz | 2.13 | |
| 19 | Nd:YAG doubled in LiIO$_3$ | 0.530 0.659 0.473-0.659 | | Temperature Temperature Temperature | | LiNbO$_3$ LiNbO$_3$ LiNbO$_3$ | S S S | 70-105mW | | 1kHz 50 pps 50 pps | 0.68-0.77 0.9-2.0 0.55-3.65 | (67% Pump Depletion (46% Avg. Power Conversion |
| 20 | ND:YAG | 1.06 | | Temperature | | LiNbO$_3$ | D | 95mW | | | 0.92 to 0.98 | OPO and Doubler Simultaneously |
| 21 | Ruby and Dye | | 4MW | | | LiNbO$_3$ | M | 6kW | | | 3 - 4 | |
| 22 | Nd:YAG doubled and redoubled | 0.2662 | 200kW | Temperature | 3 | ADP | Parametric Generator | 100 kW Peak 5 mW Avg | 2 | 30 pps | 0.42-0.73 | 25% Avg. Power Conversion |
| 23 | Ruby and Dye | | | | | Ag$_3$AsS$_3$ | M | | | | 10.1-12.7 | |
| 24 | Nd:CaWO$_4$ | 1.065 | 80kW | Angle | 26 | Ag$_3$AsS$_3$ | D | 1KW | 25 | 2 pps | 1.82-2.56 | Peak Power Conversion >1% |
| 25 | Nd:YAG | 1.064 | 1.7J/ Pulse | Angle | 100 | LiIO$_3$ | D | 13kW Peak 20mW Avg 0.2mJ/Pulse | 15 | 80 pps | 1.95-2.34 | Internal |
| | | 1.064 | 1.7J/ Pulse | Angle | 100 | LiIO$_3$ | S | | | | 3.8-4.2 | Internal |
| 26 | Nd:YAG | 1.833 | 2.4kW | Angle | | CdSe | S | 180W | | | 2.2 & 9.6 | 40% Pump Depletion |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | Nd:YAG doubled and redoubled | 0.2662 | 200kW | Temperature | 3 | ADP | Parametric Generator | 100 kW Peak 5 mW Avg | 2 | 30 pps | 0.42-0.73 | 25% Avg. Power Conversion |
| 23 | Ruby and Dye | | | | | $Ag_3AsS_3$ | M | | | | 10.1-12.7 | |
| 24 | $Nd:CaWO_4$ | 1.065 | 80kW | Angle | 26 | $Ag_3AsS_3$ | D | 1KW | 25 | 2 pps | 1.82-2.56 | Peak Power Conversion >1% |
| 25 | Nd:YAG | 1.064 | 1.7J/ Pulse | Angle | 100 | $LiIO_3$ | D | 13kW Peak 20mW Avg 0.2mJ/Pulse | 15 | 80 pps | 1.95-2.34 | Internal |
| | | 1.064 | 1.7J/ Pulse | Angle | 100 | $LiIO_3$ | S | | | | 3.8-4.2 | Internal |
| 26 | Nd:YAG | 1.833 | 2.4kW | Angle | | CdSe | S | 180W | | | 2.2 & 9.6 | 40% Pump Depletion |
| 3 | $Nd:YAlO_3$ | 1.08 | 1.3W Avg | Temperature | | $LiNbO_3$ | D | 10kW Peak 1.2W Avg | 2 | 4kHz | 2.1 | Internal |
| | $Nd:YAlO_3$ | 1.08 | | Temperature | | $LiNbO_3$ | D | 500mW Avg | | | 1.8-2.7 | Internal - 2 lines |
| | $Nd:YAlO_3$ | 1.08 | 2.65W | Temperature | | $LiNbO_3$ | D | 6kW Peak 1.8W Avg | 35 | 9kHz | 2.1 | Internal - 67% Avg. Power Conversion |
| | $Nd:YAlO_3$ | 1.08 | | Temperature | | $LiNbO_3$ | S | 160-640W Peak 50-200 mW Avg | 20 | 5.5kHz | 2.84-3.71 | Internal |
| 27 | Nd:YAG | 1.833 | 5kW | Angle | 300 | CdSe | S | | | 5 pps | 2.2 & 9.8-10.4 | 40% Pump Depletion |
| 28 | $Nd:CaWO_4$ | 1.065 | | Angle | 25 | $Ag_3AsS_3$ | S | 100 W @ 4.5 μ | | | 1.22 - 8.5 | Noncollinear |
| 29 | Ruby and Dye | | 4MW | | | $LiIO_3$ | M | 100 W | | | 4.1 - 5.2 | |
| 30 | $CaF_2:Dy^{2+}$ | 2.36 | 100kW | Angle | 60 | CdSe | S | 22.5kW | 40 | | 7.88 - 13.7 2.8 - 3.36 | 15% Energy Conv. at 90° 4% Energy Conv. at 60° |
| 31 | OPO | 1.87-2.47 | 100W | | | $Ag_3AsS_3$ | M | | | | 7.8 - 11.9 | |
| 32 | 2 Dye Lasers + Raman from Potassium Metal Vapor | | | | | Potassium | M | 100mW Peak | | | 2 - 20 | |
| 33 | Ruby and Dye | | | | | $Ag_3AsS_3$ | M | | | | 3.2 - 5.65 | |
| 34 | Ruby and Dye | | 1MW | | 10 | $AgGaS_2$ | M | | | | 4.6 - 12 | |
| 35 | Ruby and Dye | | | | | $AgAsS_3$ | M | | | | 5.82 - 7.25 | |
| 36 | Dye | 0.586-0.605 | 6.3mJ/ Pulse | Dye Tuning | | $LiNbO_3$ | S | 0.12 mJ/Pulse 160W | | 20 pps | 0.9 - 1.15 1.3 - 1.7 | 32% Pump Depletion |
| 37 | $LiNbO_3$ OPO + 1.318 Nd:YAG | | | | | $AgGaSe_2$ | M | | | | 7 - 13 | |

yielded spectral coverage from 0.548 to 3.65 μm; more recently, pumping $LiNbO_3$ with an electronically tunable dye laser[36] offered rapid selection of wavelengths in the near IR. Proustite ($Ag_3AsS_3$) pumped by Nd: $CaWO_4$ provided coverage out to 8.5 μm;[28] CdSe pumped by $CaF_2:Dy^{2+}$ reached 13.7 μm[30]. Ammann, Yarborough and Falk[20] achieved simultaneous optical parametric oscillation and frequency doubling of the signal in $LiNbO_3$ pumped by 1.06 μm to generate wavelengths higher than the initial pump. Hence, the infrared and visible spectrum of interest can be covered by parametric oscillators.

The highest IR peak powers (Figure 3) were obtained from parametric oscillators pumped by ruby lasers, [11,13,15,16] followed by the CdSe oscillator pumped by $CaF_2:Dy^{2+}$.[30] Peak powers up to 15 kilowatts have been obtained from parametric oscillators pumped by neodymium lasers. In contrast, all the high average power parametric oscillators have been pumped by neodymium lasers capable of high repetition rate performance (Figure 4). The only parametric oscillator shown in Figure 4 that was not pumped by neodymium was a CW argon laser-pumped lithium niobate oscillator.[14] It should also be noted that the parametric oscillators of References 3 and 20 were internal parametric oscillators that exposed the oscillator to the total laser flux in the cavity. The parametric oscillator of Reference 19 was pumped in the green which resulted in 90° phase matching for high average power performance.

In Figure 5, power conversion efficiency for the various parametric oscillators is shown. The highest efficiency was that of the previously mentioned degenerate oscillator[3] at 2.16 μm. Power conversion efficiency of 46% from a 0.659 μm pump to two tunable outputs was reported.[19] A 45% peak power conversion to the signal was obtained in a ruby-pumped singly resonant oscillator.[16] Conversion efficiency of 40% as measured by pump depletion

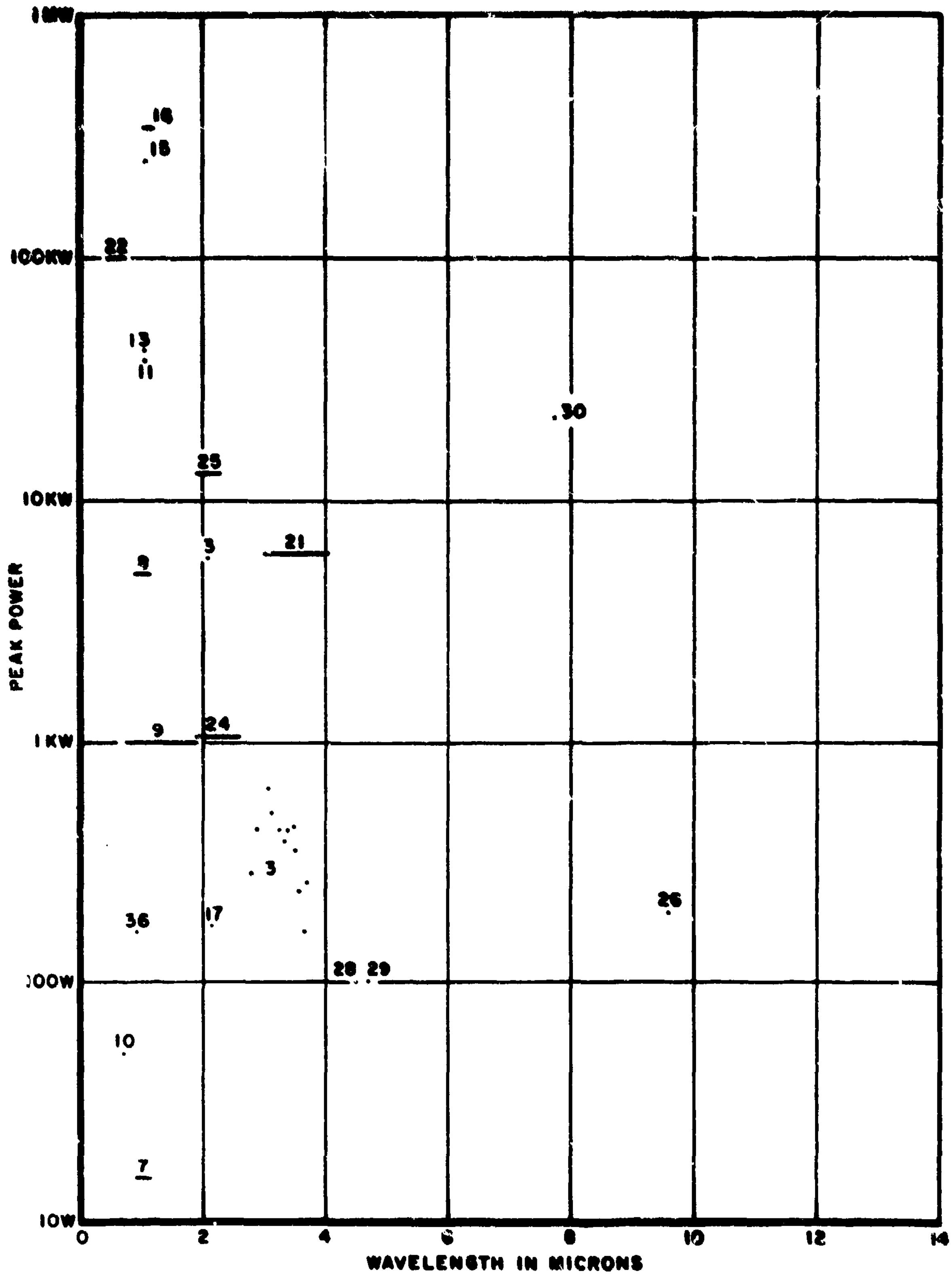


Figure 3. Peak Power vs Wavelength

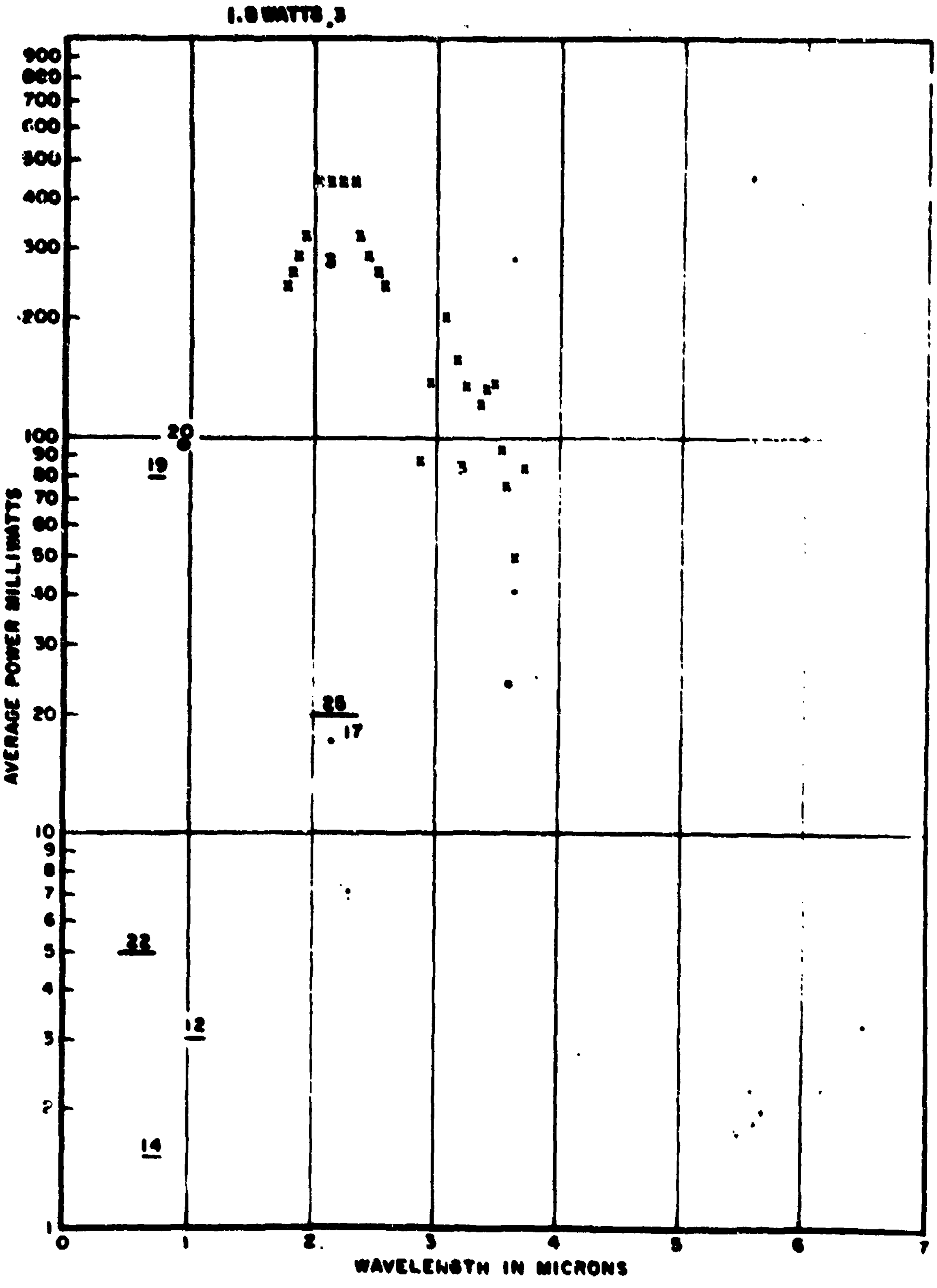


Figure 4. Average Power vs Wavelength

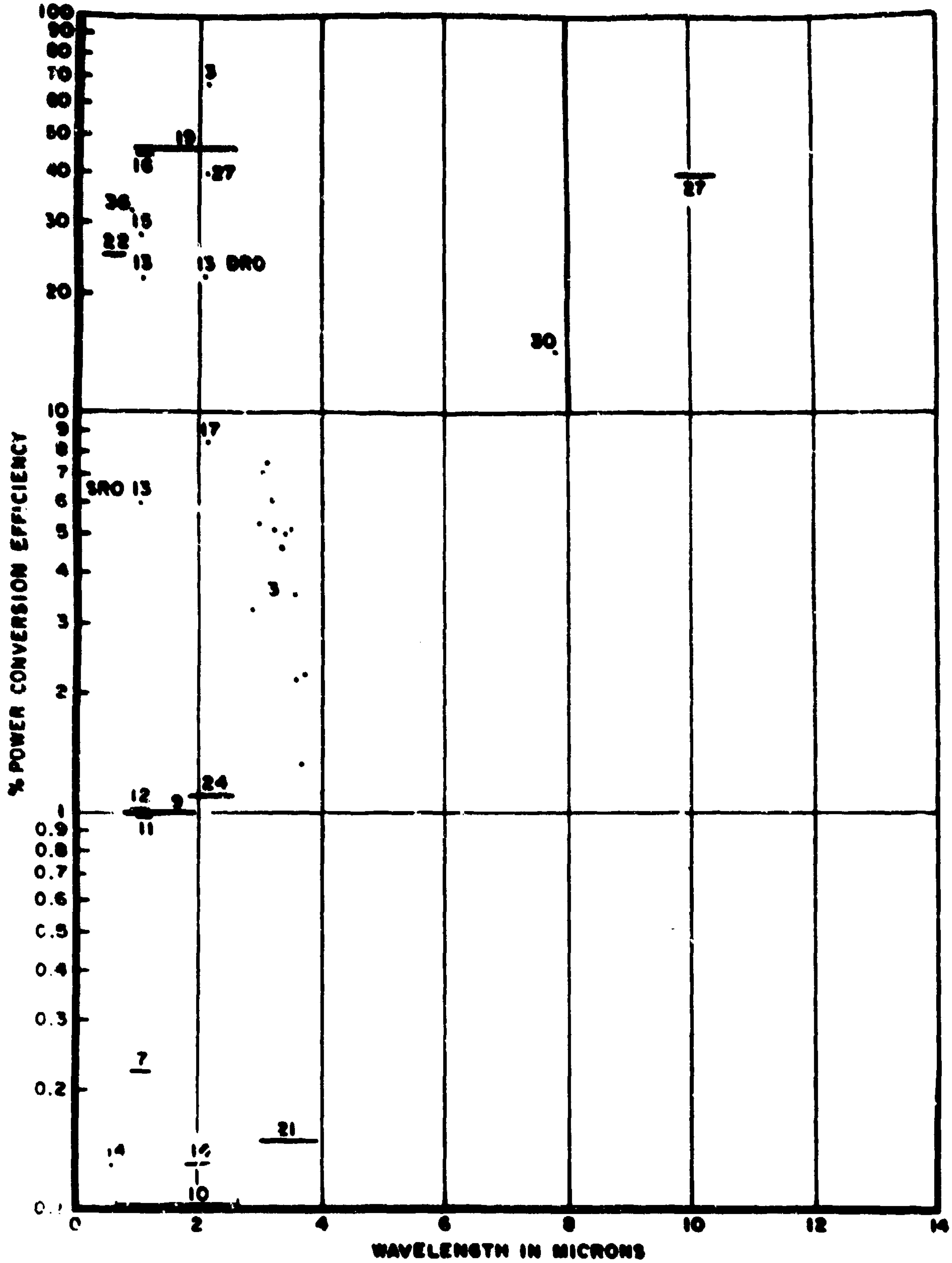


Figure 5. Power Conversion Efficiency vs Wavelength

was reported[27] for an oscillator with the signal resonated. The various means of reporting power conversion efficiencies were not totally self consistent, and in some cases, an interpretation was required. For explicit details on the efficiencies see the references and Table I.

There are three ways commonly cited to give an idea of the power conversion efficiency. Average power conversion efficiency is the ratio of the average output power of the parametric oscillator to the average input power of the pump. Peak power conversion refers to the ratio of the peak power of the parametric oscillator to that of the pump. Note from Table I that the pulse length of the oscillator is frequently shorter than that of the laser pump; this results in an apparent higher efficiency for peak power conversion because of pulse compression. Pump depletion is a measure of the amount of energy lost from the pump in passing through the parametric oscillator. This lost energy is converted to signal and idler energy in the parametric oscillator as well as absorbed and scattered in the parametric oscillator elements. Hence, not all energy measured by pump depletion is transformed to useful parametric oscillator output.

Parametric oscillators of lithium niobate have been tuned by angle, by temperature, and by the electrooptic effect (Table I). The bringing of the crystal to thermal equilibrium at new temperatures changes the indices of refraction, and hence, the frequency of the parametric oscillator. This process is a slower tuning technique than that of merely rotating the crystal. The technique of changing parametric oscillator frequency by changing the wavelength of the dye laser pump has been recently demonstrated using an acousto-optic filter.[36] This offers random frequency selection within the limits of the dye laser pump and maximum flexibility since

frequencies can be shifted on a pulse to pulse basis. Electrooptic effect tuning[11] demonstrated a frequency shift of 6.2 A°/kV/cm in $LiNbO_3$, so it cannot be effectively used for large frequency excursions because of the voltage involved.

Bjorkholm succinctly points out[13], "The advantage of a singly resonant oscillator is that it should be much more nearly continuously tunable than a doubly resonant oscillator. In the latter, because of the accidental distribution of the signal and idler cavity modes, frequency excursions from the operating point predicted by index-matching data can be large with respect to the axial mode spacing of the oscillator (~0.1A°). For the singly resonant oscillator, the tuning discontinuities should be no larger than one-half the mode spacing." In another article[15] Bjorkholm remarks that the tunability of the SRO is at least five times and probably an order of magnitude more accurate than the tunability of the DRO.

## SECTION III

## TUNABLE MIXERS

Coherent infrared radiation can also be produced as the difference frequency generated when two coherent sources, the pump and the signal waves, are mixed in a suitable nonlinear crystal at the proper phase matching angle. Table II lists typical pump wavelengths and corresponding signal wavelengths required to generate IR wavelengths from 2 to 12 μm. Again, the energy and momentum relationships ($\omega_p - \omega_s = \omega_i$ and $\underline{k}_p - \underline{k}_s = \underline{k}_i$, respectively) must be satisfied to have efficient power transfer.

Most experiments to date have utilized single pass systems which do not require optical cavities and associated mirrors. Such systems offer the advantage of simplicity, but sacrifice the more efficient utilization of input power through multiple reflections in the cavity. However, crystals of very high optical quality are required for use in optical parametric oscillators, whereas poorer quality crystals can be used in mixers.

In January 1971, Dewey and Hocker[21] reported infrared difference frequency generation by mixing the inputs of a Q-switched ruby laser and a tunable dye laser in a $LiNbO_3$ crystal. In their experiment, the output of an unpolarized Q-switched ruby laser was separated into two parts by a beam splitter. One beam pumped a tunable dye laser. The output from the dye laser was then combined with the second part of the ruby beam and directed into the $LiNbO_3$ crystal which was rotated to maintain the proper phase matching angle for different wavelengths. Pulses of approximately 6 KW of peak power were produced in the 3 to 4 μm range for an initial input of 4 MW from the ruby laser.

TABLE II. SIGNAL WAVELENGTHS REQUIRED TO GENERATE IR WAVELENGTHS FROM 2 TO 12 μm FOR SPECIFIED PUMP WAVELENGTHS

| $\lambda_i$ (μm) | $\lambda_p$ (μm) | $\lambda_s$ (μm) | | $\lambda_p$ (μm) | $\lambda_s$ (μm) | | $\lambda_p$ (μm) | $\lambda_s$ (μm) | | $\lambda_p$ (μm) | $\lambda_s$ (μm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 | 0.53 | 0.419 | 0.721 | 0.694 | 0.515 | 1.063 | 0.946 | 0.642 | 1.795 | 1.06 | 0.693 | 2.255 |
| 3.0 | | 0.450 | 0.644 | | 0.564 | 0.903 | | 0.719 | 1.382 | | 0.783 | 1.639 |
| 4.0 | | 0.468 | 0.611 | | 0.591 | 0.840 | | 0.765 | 1.239 | | 0.838 | 1.442 |
| 5.0 | | 0.479 | 0.593 | | 0.609 | 0.806 | | 0.795 | 1.167 | | 0.875 | 1.345 |
| 6.0 | | 0.487 | 0.561 | | 0.622 | 0.785 | | 0.817 | 1.123 | | 0.901 | 1.287 |
| 7.0 | | 0.493 | 0.573 | | 0.631 | 0.770 | | 0.833 | 1.094 | | 0.921 | 1.249 |
| 8.0 | | 0.497 | 0.568 | | 0.639 | 0.760 | | 0.846 | 1.073 | | 0.936 | 1.222 |
| 9.0 | | 0.501 | 0.563 | | 0.644 | 0.752 | | 0.856 | 1.057 | | 0.948 | 1.202 |
| 10.0 | | 0.503 | 0.560 | | 0.649 | 0.746 | | 0.864 | 1.045 | | 0.958 | 1.186 |
| 11.0 | | 0.506 | 0.557 | | 0.653 | 0.741 | | 0.871 | 1.035 | | 0.967 | 1.173 |
| 12.0 | | 0.508 | 0.554 | | 0.656 | 0.737 | | 0.877 | 1.027 | | 0.974 | 1.163 |
| 2.0 | 1.30 | 0.788 | 3.714 | 1.83 | 0.956 | 21.53 | 2.10 | 1.024 | --- | | | |
| 3.0 | | 0.907 | 2.294 | | 1.137 | 4.692 | | 1.235 | 7.000 | | | |
| 4.0 | | 0.981 | 1.926 | | 1.256 | 3.373 | | 1.377 | 4.421 | | | |
| 5.0 | | 1.032 | 1.757 | | 1.340 | 2.886 | | 1.479 | 3.621 | | | |
| 6.0 | | 1.068 | 1.660 | | 1.402 | 2.633 | | 1.556 | 3.231 | | | |
| 7.0 | | 1.096 | 1.597 | | 1.451 | 2.478 | | 1.615 | 3.000 | | | |
| 8.0 | | 1.118 | 1.552 | | 1.489 | 2.373 | | 1.663 | 2.847 | | | |
| 9.0 | | 1.136 | 1.539 | | 1.521 | 2.297 | | 1.703 | 2.739 | | | |
| 10.0 | | 1.150 | 1.494 | | 1.547 | 2.240 | | 1.736 | 2.658 | | | |
| 11.0 | | 1.163 | 1.474 | | 1.569 | 2.195 | | 1.763 | 2.596 | | | |
| 12.0 | | 1.173 | 1.458 | | 1.588 | 2.159 | | 1.787 | 2.545 | | | |

The dye laser mixing technique was extended further into the IR region by Hanna, Smith, and Stanley[illegible] when they reported (December 1971) that they had mixed the outputs of a ruby laser and a tunable dye laser (pumped by the ruby laser) in a proustite crystal to generate peak powers of a few watts at approximately 5 μm and over a range of 10.1 to 12.7 μm.

In June 1972, Meltzer and Goldberg[29] obtained tunable difference frequency generation in $LiIO_3$ over a range of 4.1 to 5.2 μm. They mounted the $LiIO_3$ crystal inside the dye laser cavity. The dye cell was pumped by a ruby laser and tuned with a diffraction grating. Phase matching was achieved by rotation of the crystal. IR output pulses of approximately 100 W peak power at 4.7 μm were obtained for a total ruby laser input of 4 MW. The dye laser power was approximately 70 kW.

In December 1972, Bhar, Hanna, Luther-Davies, and Smith[31] reported the use of an OPO as their tunable source to generate two input wavelengths which, when mixed in a proustite crystal, produced tunable IR radiation over a range of 7.8 to 11.9 μm. The OPO was tuned from 1.87 to 2.47 μm. The total input power to the crystal was approximately 100 W.

Down-converted IR radiation from 4.6 to 12 μm was reported by Hanna, Rampal and Smith[34] in June 1973 when they mixed a ruby laser beam in silver thiogallate ($AgGaS_2$) with the output of various ruby-pumped dye lasers. The Q-switched ruby laser produced a peak output power of 1 MW ($TEM_{00}$ mode) with a pulse duration of 10 nsec (fwhm). Part of this power was separated by a beam splitter and was used to pump the dye laser. Four separate dyes were used to cover the 4.6 to 12 μm spectral range. Peak powers of hundreds of milliwatts were produced.

Decker and Tittel[33,35] reported (April 1973 and July 1973) tunable difference frequency generation in proustite over the range 3.2 to 5.65 μm with a Q-switched ruby laser and tunable dye laser and over the range 5.82 to 7.25 μm with the outputs of two independent ruby pumped dye lasers. Peak IR powers up to several KW were obtained.

Byer, Choy, Herbst, Chemla, and Feigelson[37] recently reported (January 1974) continuously tunable IR difference frequency generation in silver gallium selenide ($AgGaSe_2$) over the range 7 to 13 μm by mixing the outputs from a $LiNbO_3$ parametric oscillator. A 1.318 μm output from a Nd:YAG laser was doubled by a $LiIO_3$ crystal to obtain 0.659 μm which in turn pumped a $LiNbO_3$ temperature-tuned oscillator to produce a 1.62 to 1.47 μm signal. This signal was matched with the 1.318 μm pump to produce the 7 to 13 μm IR radiation.

Tunable coherent infrared radiation produced in a four-wave mixing process was reported in April 1973 by Sorokin, Wynne, and Lankard[32]. The mixing process was achieved by utilizing resonant enhancement of a third order optical nonlinearity in an alkali metal vapor (potassium at 500°C). A 100 kW nitrogen laser was used to simultaneously pump two dye lasers whose outputs were focused into a heat pipe oven containing the metal vapor. The beam from the first dye laser at frequency $\omega_1$, which was tuned to the 4s-5p resonance lines of potassium (0.404 μm), induced radiation (a Stokes wave) at frequency $\omega_2$ by stimulated Raman scattering between the 5p-5s levels. The beam from the second dye laser at frequency $\omega_3$ then "beat" together with the first two waves to create a fourth wave at frequency $\omega_4$ (in the infrared) such that $\omega_4 = \omega_1 - \omega_2 - \omega_3$ (the energy matching relationship). The corresponding momentum relationship that had to be

satisfied was $\Delta n_4\omega_4 = \Delta n_1\omega_1 - \Delta n_2\omega_2 - \Delta n_3\omega_3$ where $\Delta n$ is the dispersion in the refractive index. By changing the laser dyes and by mixing small amounts of other gases with the potassium vapor, it was possible to obtain continuously variable wavelengths from 2 to 20 μm. IR peak power outputs up to 100 μW were obtained.

Mixing experiments reported to date have demonstrated the feasibility of generating tunable infrared coherent radiation at very low power levels in a number of different materials. For the most part, pump sources have been single shot or low repetition rate lasers with outputs in the visible. To achieve worthwhile power levels requires that the two input sources, one of which must be tunable, operate in the 1-2.5 μm region for increased efficiency. The lack of a suitable high power tunable source at these wavelengths is a serious limitation at present.

## SECTION IV

## THEORETICAL PERFORMANCE OF NONLINEAR OPTICAL MATERIALS

The theory of parametric interaction of confocally focused light beams[38] was used to provide a basis for comparing materials for parametric generation of tunable radiation in the 2-6 and 8-12 μm regions. The effects of walkoff due to birefringence were taken into account.

The materials used in the comparison are listed in Table III along with the nonlinear coefficients used in the calculations. The refractive indices used were obtained from the references also listed in Table III. For completeness we have compiled in Appendix A the room temperature index data and Sellmeier equations for each material. The list of materials is not comprehensive but does contain materials already used in nonlinear optical devices as well as several promising materials recently synthesized. Of the 11 materials listed in Table III, only $LiNbO_3$ and $LiIO_3$ are commercially available. All the other materials are in various stages of development. Of the nine non-commercially available materials listed in Table III, both $Ag_3AsS_3$[18,24,28] and CdSe[26,27,30] have been used in infrared parametric oscillators. Also, $Ag_3AsS_3$,[31,33,35] $AgGaS_2$,[34] and $AgGaSe_2$[37] have been used for infrared mixing. These materials, then, may be considered to be the most advanced of the nine experimental nonlinear materials.

In Figures 6 to 12, curves of the parametric gain per watt of pump power as a function of oscillator output wavelength are given for the pump wavelengths 0.694, 0.946, 1.06, 1.3, 1.83, 2.1, and 5.3 μm, respectively. All of the materials of Table III that can be phase matched and which are transparent at a given pump wavelength are included in each figure. A crystal length of one cm was assumed in all cases. Each curve extends over

## TABLE III NONLINEAR OPTICAL MATERIALS

| Material | Crystal Class | Birefringence Type | NLO Coefficients ($\times 10^{12}/\varepsilon_o$, m/V) | Refractive Indices | $d_{eff}(\theta)$ |
|---|---|---|---|---|---|
| $AgGaS_2$ | $\bar{4}2m$ | Negative | $\|d_{36}\| = 12$ (Ref 39)<br>$\|d_{14}\| \simeq \|d_{36}\|$ | Ref. 39,40 | $\|d_{36}\|\sin\theta$ (Type I)<br>$(\|d_{14}\|+\|d_{36}\|)\sin\theta\cos\theta$ (Type II) |
| $AgGaSe_2$ | $\bar{4}2m$ | Negative | $\|d_{36}\| = 33$ (Ref 41)<br>$\|d_{14}\| \simeq \|d_{36}\|$ | Ref. 41,42 | |
| $CdGeAs_2$ | $\bar{4}2m$ | Positive | $\|d_{14}\| = 236$ (Ref 43) | Ref. 43,44 | $\|d_{14}\|\sin 2\theta$ (Type I)<br>$\|d_{14}\|\sin\theta$ (Type II) |
| $ZnGeP_2$ | $\bar{4}2m$ | Positive | $\|d_{14}\| = 75$ (Ref 45) | Ref. 45 | |
| HgS | 32 | Positive | $\|d_{11}\| = 50$ (Ref 46)<br>$\|d_{14}\| \approx 0$ | Ref. 47,48 | $\|d_{11}\|\cos^2\theta+\|d_{14}\|\sin 2\theta$ (Type I)<br>$\|d_{11}\|\cos\theta$ (Type II) |
| $Ag_3AsS_3$ | 3m | Negative | $\|d_{21}\| = 25.6$ (Ref 49)<br>$\|d_{31}\| = 16.0$ | Ref. 48,50 | $\|d_{21}\|\cos\theta+\|d_{31}\|\sin\theta$ (Type I)<br>$\|d_{21}\|\cos^2\theta$ (Type II) |
| $Ag_3SbS_3$ | 3m | Negative | $\|d_{21}\| = 13.4$ (Ref 51)<br>$\|d_{31}\| = 12.6$ | Ref. 52 | |
| $LiNbO_3$ | 3m | Negative | $\|d_{21}\| = 3.6$ (Ref 53)<br>$\|d_{31}\| = 6.25$ | Ref. 48,54 | |
| $Tl_3AsSe_3$ | 3m | Negative | $\|d_{21}\| = 44.2$ (Ref 55)<br>$\|d_{31}\| = 41.6$ | Ref. 55 | |
| $LiIO_3$ | 6 | Negative | $\|d_{31}\| = 7.5$ (Ref 56)<br>$\|d_{14}\| \simeq 0$ | Ref. 56,57 | $\|d_{31}\|\sin\theta$ (Type I)<br>$\|d_{14}\|\sin\theta\cos\theta$ (Type II) |
| CdSe | 6mm | Negative | $\|d_{31}\| = 19$ (Ref 58) | Ref. 31 | $\|d_{31}\|\sin\theta$ (Type I)<br>0 (Type II) |

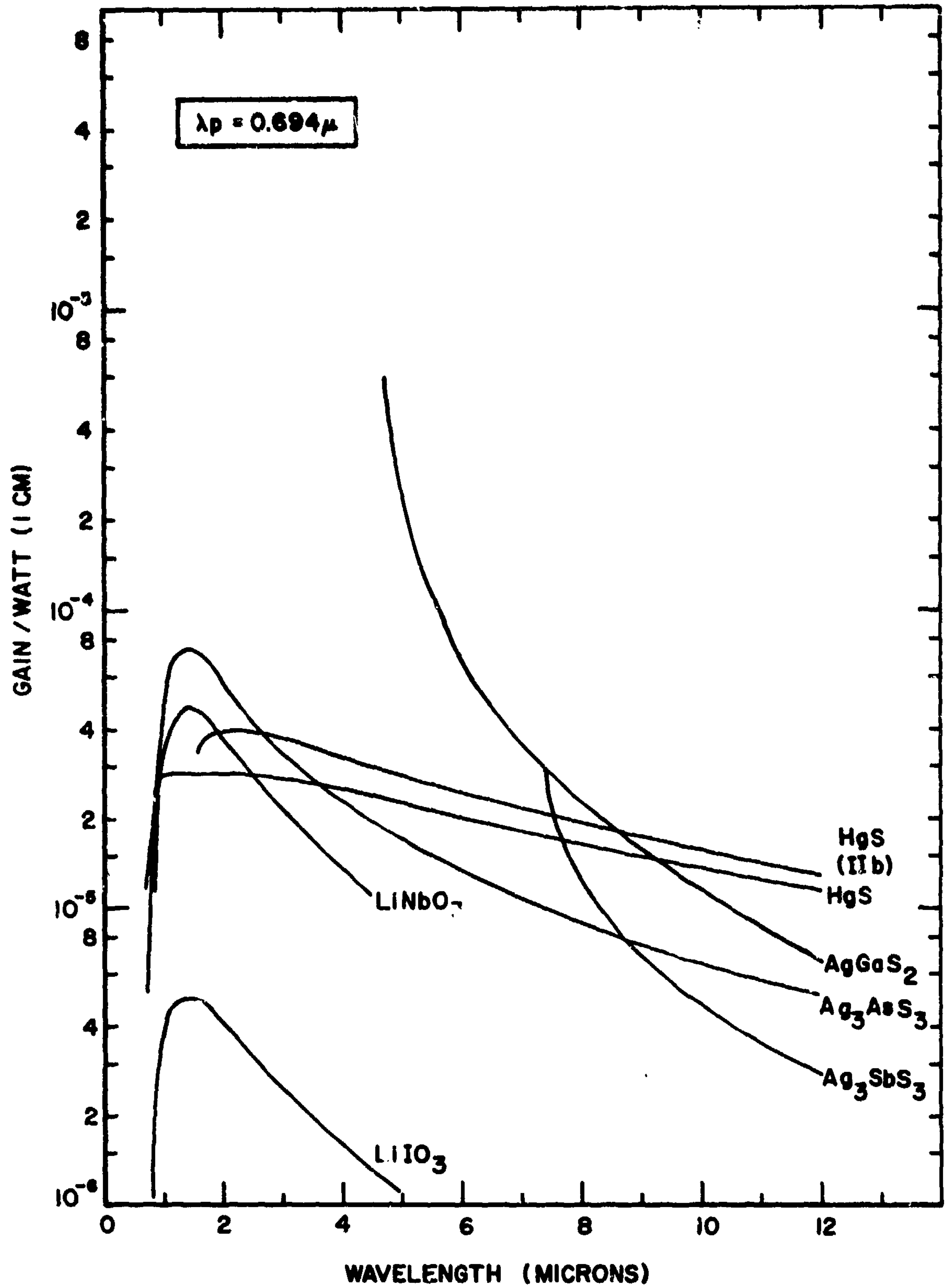


Figure 6. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 0.694 μm. A Crystal Thickness of 1 cm is Assumed. Curves are for Type I Phase Matching Unless Otherwise Noted.

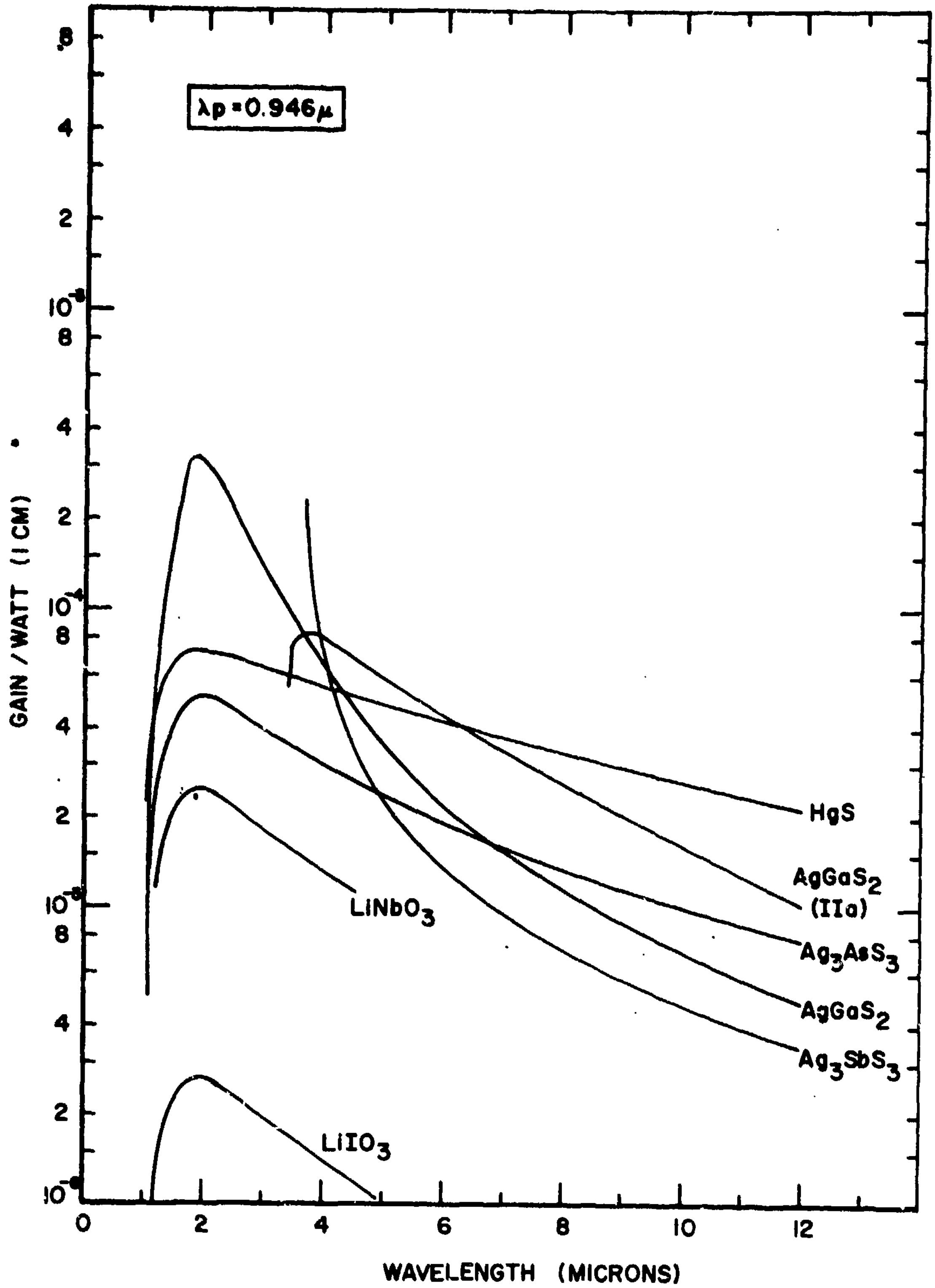


Figure 7. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 0.946 μm. Curves are for Type I Phase Matching Unless Otherwise Noted.

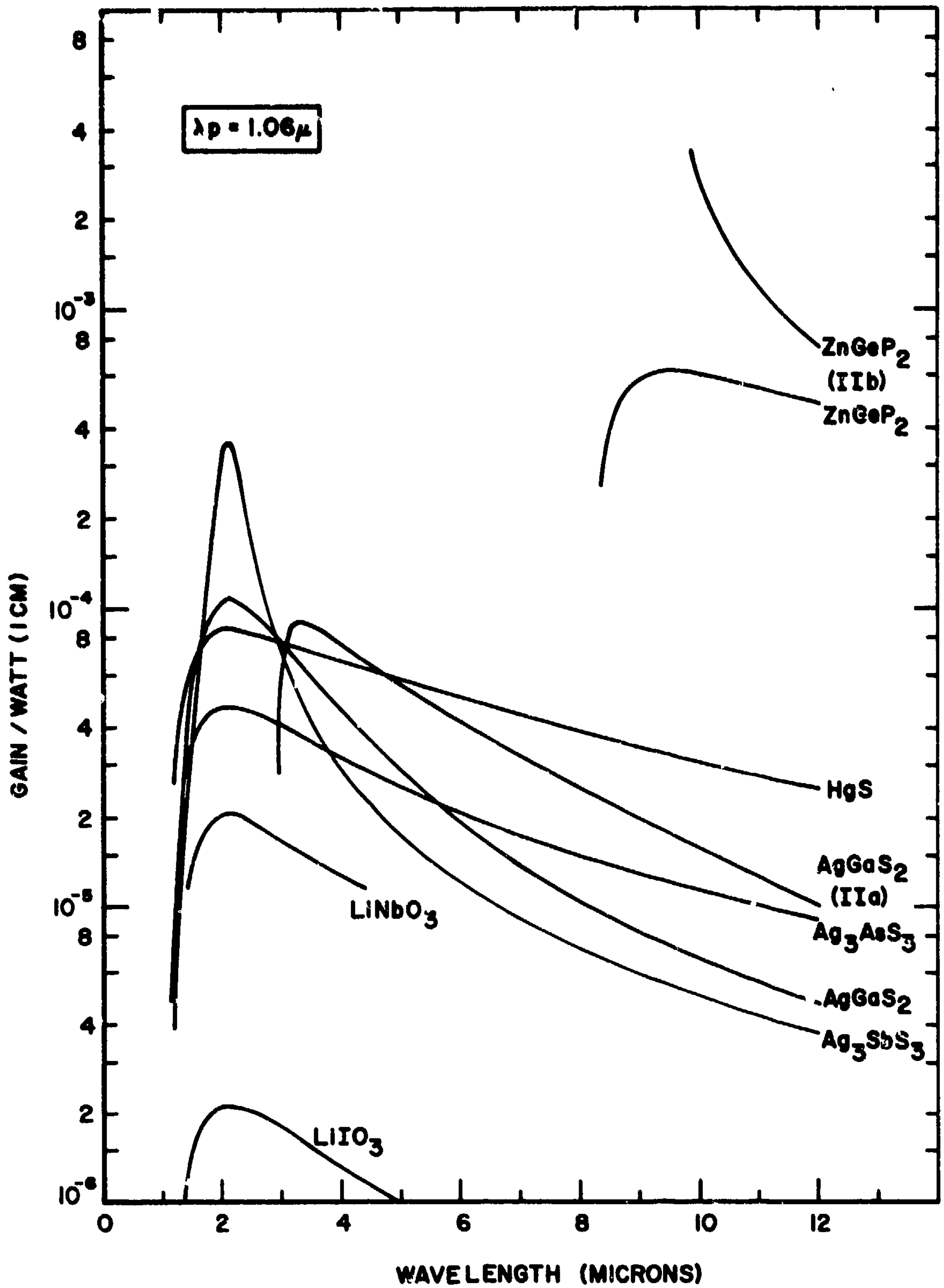


Figure 8. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 1.06 μm. Curves are for Type I Phase Matching Unless Otherwise Noted.

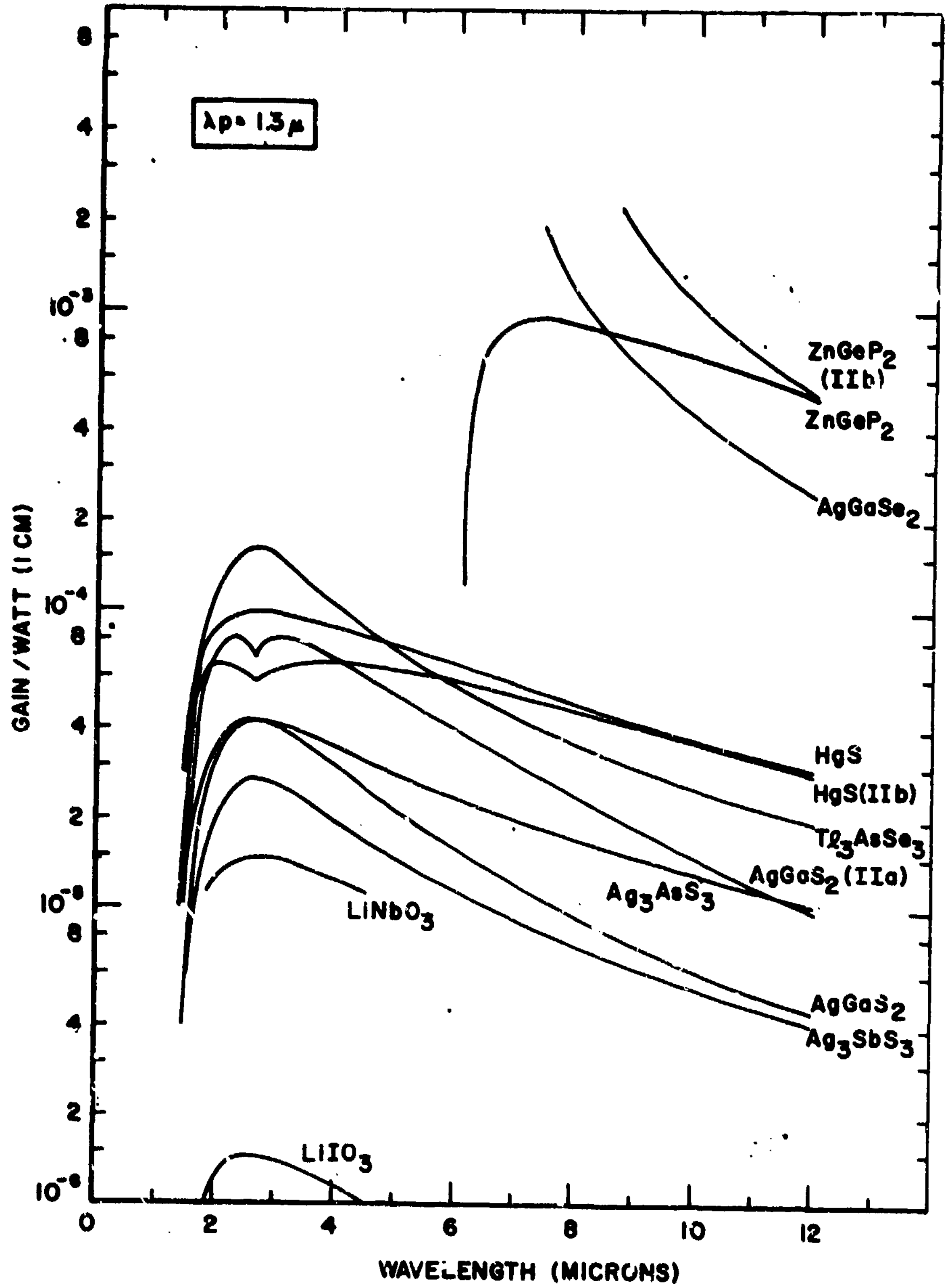


Figure 9. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 1.3 μm. Curves are for Type I Phase Matching Unless Otherwise Noted.

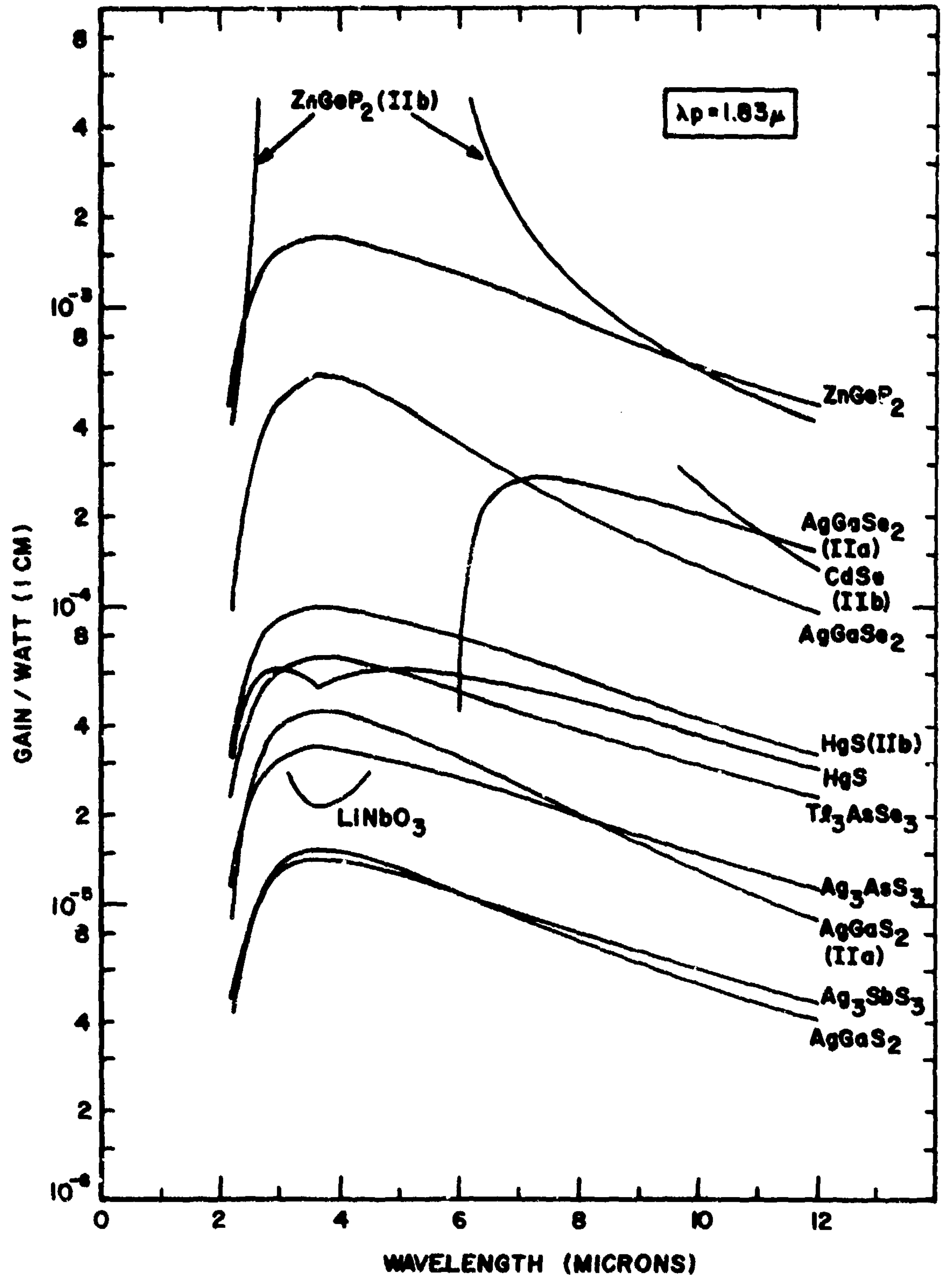


Figure 10. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 1.83 μm. Curves are for Type I Phase Matching Unless Otherwise Noted.

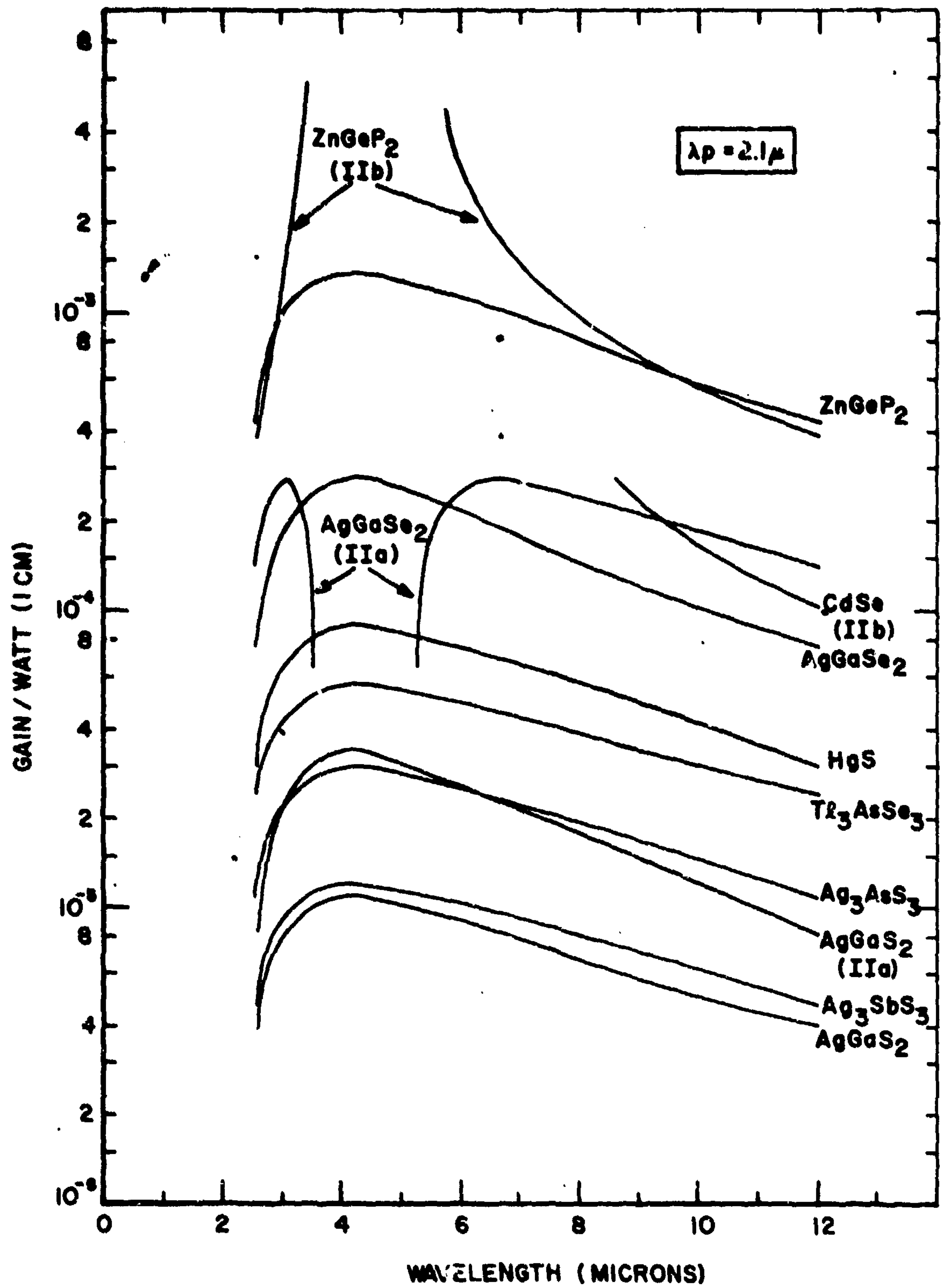


Figure 11. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 2.1 μm. Curves are for Type I Phase Matching Unless Otherwise Noted.

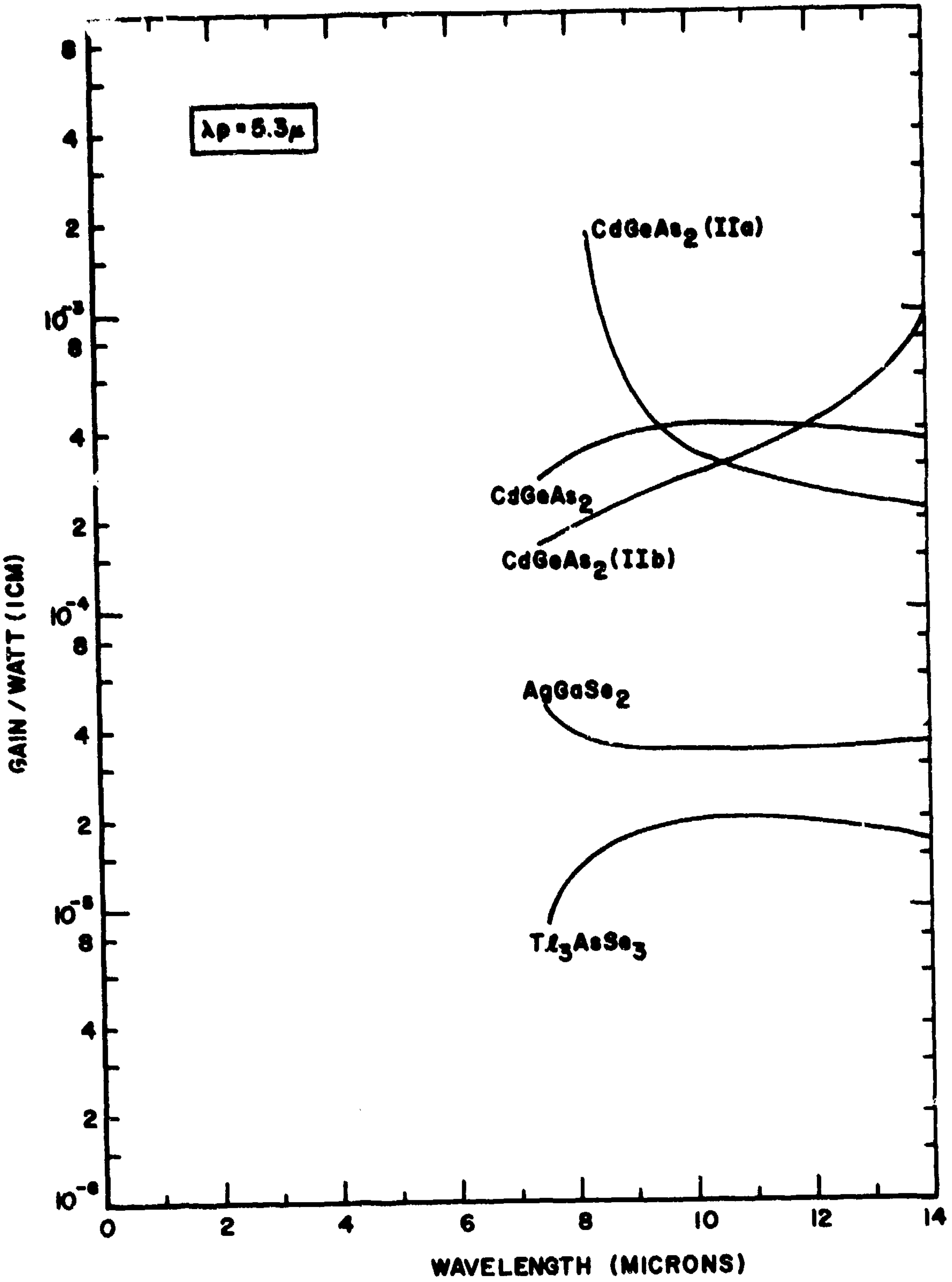


Figure 12. Parametric Gain Per Watt vs Output Wavelength for a Pump Wavelength of 5.3 μm. Curves are for Type I Phase Matching Unless Otherwise Noted.

the transparency range of the material. In the case of the phosphides and sulfides, however, the longest practical wavelength is limited by multiphonon absorption to about 10 μm. The Roman numerals beside each material identify the type of phase matching (see the definitions given in Table IV). In cases where both Type I and Type II phase matching are possible, only the higher gain curve is shown if (as, for example, in the case of $Ag_3AsS_3$) the gains for the two types differ by a large factor. In cases where the gains for both types of phase matching are comparable, both curves are given. In previously published comparisons of materials,[5,6] parametric gains are displayed as horizontal lines vs wavelength (denoting only the transparency range), and different pump wavelengths are included on the same diagram. The actual gain curves, their crossings, and their relative shifts from one pump wavelength to another, as seen in Figures 6 to 12, show that a simple composite diagram can be misleading.

High gain implies a low pumping power required to reach oscillator threshold. Thus, to build a practical device, one must select a material with sufficient gain to reach threshold and, ideally, saturation at a power level within the state-of-the-art of the pump laser. However, gain is a necessary but not a sufficient criterion on which to base the choice. If the high gain can be achieved only by such tight focusing that the pump power density exceeds the material's damage threshold, then obviously the material cannot be used. Other criteria are availability and optical quality of the material, and the availability of suitable anti-reflecting and high reflecting coatings.

To answer the question of power density requirements, we present a detailed comparison of materials at the pump wavelengths 0.694, 1.06, 1.3, and 2.1 μm in Tables V to VIII, respectively. These pump wavelengths are representative of the ruby, $Nd^{3+}$, and $Ho^{3+}$ solid state lasers.

TABLE IV DEFINITION OF PHASE MATCHING TYPES

| Birefringence Type | Phase Matching Type | Beam Polarizations | | |
|---|---|---|---|---|
| | | Signal ($\lambda_s < \lambda_p/2$) | Idler ($\lambda_i > \lambda_p/2$) | Pump |
| Positive ($n^e > n^o$) | I | e | e | o |
| | IIa | o | e | o |
| | IIb | e | o | o |
| Negative ($n^e < n^o$) | I | o | o | e |
| | IIa | o | e | e |
| | IIb | e | o | e |

TABLE V. COMPARISON OF PARAMETRIC OSCILLATOR PERFORMANCE OF MATERIALS AT A PUMP WAVELENGTH OF 0.694 μm

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) SRO | $P_t$ (KW) DRO | $P_s$ (KW) SRO | $P_s$ (KW) DRO | A ($cm^2$) x $10^5$ | $P_t/A$ ($MW/cm^2$) SRO | $P_t/A$ ($MW/cm^2$) DRO | $P_s/A$ ($MW/cm^2$) SRO | $P_s/A$ ($MW/cm^2$) DRO | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $AgGaS_2$ (I) | 0.81 | 4.73 | 59 | 0.34 | 0.017 | 0.84 | 0.068 | 1.4 | 24 | 1.2 | 58 | 4.7 | 0.85 | 0.15 |
| | 0.78 | 6 | 6.9 | 2.9 | 0.14 | 7.2 | 0.58 | 5.1 | 57 | 2.8 | 140 | 11 | 0.86 | 0.12 |
| | 0.76 | 8 | 2.2 | 9.2 | 0.46 | 23 | 1.8 | 8.2 | 110 | 5.6 | 280 | 22 | 0.91 | 0.09 |
| | 0.75 | 10 | 1.2 | 17 | 0.87 | 43 | 3.5 | 9.0 | 190 | 9.7 | 480 | 39 | 0.93 | 0.07 |
| $Ag_3AsS_3$ (I) | 1.39 | 1.39 | 7.4 | (2.7) | 0.14 | (6.7) | 0.54 | 150 | (1.8) | 0.089 | (4.4) | 0.36 | 0.50 | 0.50 |
| | 1.06 | 2 | 5.8 | 3.5 | 0.17 | 8.5 | 0.69 | 160 | 2.1 | 0.11 | 5.2 | 0.42 | 0.65 | 0.35 |
| | 0.84 | 4 | 2.3 | 8.7 | 0.43 | 21 | 1.7 | 170 | 5.0 | 0.25 | 12 | 1.0 | 0.83 | 0.17 |
| | 0.78 | 6 | 1.3 | 15 | 0.77 | 38 | 3.1 | 150 | 10 | 0.51 | 25 | 2.0 | 0.88 | 0.12 |
| | 0.76 | 8 | 0.89 | 22 | 1.1 | 55 | 4.5 | 130 | 17 | 0.85 | 42 | 3.4 | 0.91 | 0.09 |
| | 0.75 | 10 | 0.67 | 30 | 1.5 | 74 | 6.0 | 120 | 26 | 1.3 | 63 | 5.1 | 0.93 | 0.07 |
| $LiNbO_3$ (I) | 1.39 | 1.39 | 4.8 | (4.2) | 0.21 | (10) | 0.84 | 29 | (15) | 0.73 | (36) | 2.9 | 0.50 | 0.50 |
| | 1.06 | 2 | 3.8 | 5.3 | 0.27 | 13 | 1.1 | 30 | 18 | 0.90 | 44 | 3.6 | 0.65 | 0.35 |
| | 0.84 | 4 | 1.4 | 14 | 0.72 | 36 | 2.9 | 31 | 47 | 2.3 | 120 | 9.4 | 0.83 | 0.17 |
| HgS (IIb) | 1.24 | 1.58 | 3.4 | 5.9 | 0.29 | 14 | 1.2 | 11 | 55 | 2.8 | 140 | 11 | 0.56 | 0.44 |
| | 1.06 | 2 | 3.9 | 5.0 | 0.25 | 13 | 1.0 | 140 | 3.7 | 0.18 | 9.1 | 0.74 | 0.65 | 0.35 |
| | 0.84 | 4 | 3.2 | 6.2 | 0.31 | 15 | 1.2 | 190 | 3.3 | 0.16 | 8.1 | 0.65 | 0.83 | 0.17 |
| | 0.78 | 6 | 2.4 | 8.2 | 0.41 | 20 | 1.6 | 160 | 5.3 | 0.26 | 13 | 1.1 | 0.88 | 0.12 |
| | 0.76 | 8 | 1.9 | 10 | 0.52 | 26 | 2.1 | 130 | 8.0 | 0.40 | 20 | 1.6 | 0.91 | 0.09 |
| | 0.75 | 10 | 1.6 | 13 | 0.64 | 31 | 2.5 | 110 | 11 | 0.57 | 28 | 2.3 | 0.93 | 0.07 |
| HgS (I) | 1.39 | 1.39 | 2.9 | (7.0) | 0.35 | (17) | 1.4 | 180 | (3.9) | 0.20 | (9.7) | 0.79 | 0.50 | 0.50 |
| | 1.06 | 2 | 2.8 | 7.0 | 0.35 | 17 | 1.4 | 190 | 3.7 | 0.19 | 9.2 | 0.75 | 0.65 | 0.35 |
| | 0.84 | 4 | 2.5 | 8.0 | 0.40 | 20 | 1.6 | 170 | 4.6 | 0.23 | 11 | 0.92 | 0.83 | 0.17 |
| | 0.78 | 6 | 2.0 | 10 | 0.50 | 24 | 2.0 | 140 | 6.9 | 0.34 | 17 | 1.4 | 0.88 | 0.12 |
| | 0.76 | 8 | 1.6 | 12 | 0.61 | 30 | 2.4 | 120 | 9.9 | 0.49 | 24 | 2.0 | 0.91 | 0.09 |
| | 0.75 | 10 | 1.4 | 14 | 0.72 | 36 | 2.9 | 110 | 13 | 0.67 | 33 | 2.7 | 0.93 | 0.07 |
| $Ag_3SbS_3$ (I) | 0.77 | 7.44 | 2.3 | 8.7 | 0.44 | 21 | 1.7 | 12 | 70 | 3.5 | 170 | 14 | 0.91 | [illegible] |
| | 0.76 | 8 | 1.2 | 17 | 0.85 | 42 | 3.4 | 24 | 70 | 3.5 | 170 | 14 | 0.91 | 0.09 |
| | 0.75 | 10 | 0.047 | 43 | 2.1 | 100 | 8.5 | 48 | 89 | 4.4 | 220 | 18 | 0.93 | 0.07 |

TABLE V. (Continued)

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) | | $P_s$ (KW) | | A ($cm^2$) x $10^5$ | $P_t/A$ (MW/$cm^2$) | | $P_s/A$ (MW/$cm^2$) | | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SRO | DRO | SRO | DRO | | SRO | DRO | SRO | DRO | | |
| $LiIO_3$ (1) | 1.39 | 1.39 | 0.50 | (40) | 2.0 | (99) | 8.0 | 47 | (86) | 4.3 | (210) | 17 | 0.50 | 0.50 |
| | 1.06 | 2 | 0.41 | 49 | 2.5 | 120 | 9.8 | 45 | 110 | 5.5 | 270 | 22 | 0.65 | 0.35 |
| | 0.84 | 4 | 0.16 | 120 | 6.2 | 310 | 25 | 41 | 300 | 15 | 760 | 61 | 0.83 | 0.17 |
| | 0.79 | 5.5 | 0.096 | 210 | 10 | 510 | 42 | 42 | 500 | 25 | 1200 | 100 | 0.87 | 0.13 |

TABLE VI. COMPARISON OF PARAMETRIC OSCILLATOR PERFORMANCE OF MATERIALS AT A PUMP WAVELENGTH OF 1.06 μm

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) | | $P_s$ (KW) | | A ($cm^2$) x $10^5$ | $P_t/A$ ($MW/cm^2$) | | $P_s/A$ ($MW/cm^2$) | | $\frac{\omega_s}{\omega_p}$ | $\frac{\omega_i}{\omega_p}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SRO | DRO | SRO | DRO | | SRO | DRO | SRO | DRO | | |
| $ZnGeP_2$ (IIb) | 1.19 | 9.55 | 550 | 0.036 | 0.0018 | 0.090 | 0.073 | 1.7 | 2.2 | 0.11 | 5.4 | 0.44 | 0.89 | 0.11 |
| | 1.19 | 10 | 270 | 0.074 | 0.0037 | 0.18 | 0.015 | 1.7 | 4.4 | 0.22 | 11 | 0.88 | 0.89 | 0.11 |
| $ZnGeP_2$ (I) | 1.21 | 8.37 | 27 | 0.74 | 0.037 | 1.8 | 0.15 | 1.7 | 45 | 2.2 | 110 | 8.9 | 0.87 | 0.13 |
| | 1.20 | 9 | 58 | 0.35 | 0.017 | 0.86 | 0.69 | 1.7 | 21 | 1.0 | 51 | 4.2 | 0.88 | 0.12 |
| | 1.19 | 10 | 61 | 0.33 | 0.016 | 0.81 | 0.66 | 1.7 | 20 | 0.99 | 49 | 4.0 | 0.89 | 0.11 |
| $Ag_3SbS_3$ (I) | 2.12 | 2.12 | 36 | (0.55) | 0.028 | (1.4) | 0.11 | 2.6 | (22) | 1.1 | (54) | 4.3 | 0.50 | 0.50 |
| | 1.64 | 3 | 6.9 | 2.9 | 0.14 | 7.1 | 0.57 | 18 | 16 | 0.81 | 40 | 3.2 | 0.65 | 0.35 |
| | 1.44 | 4 | 2.9 | 7.0 | 0.35 | 17 | 1.4 | 37 | 19 | 0.95 | 47 | 3.8 | 0.73 | 0.27 |
| | 1.29 | 6 | 1.2 | 17 | 0.83 | 41 | 3.3 | 53 | 31 | 1.6 | 77 | 6.3 | 0.82 | 0.18 |
| | 1.22 | 8 | 0.72 | 28 | 1.4 | 69 | 5.6 | 55 | 51 | 2.5 | 120 | 10 | 0.87 | 0.13 |
| | 1.19 | 10 | 0.49 | 41 | 2.0 | 100 | 8.2 | 53 | 76 | 3.8 | 190 | 15 | 0.89 | 0.11 |
| $AgGaS_2$ (I) | 2.12 | 2.12 | 11 | (1.9) | 0.093 | (4.6) | 0.37 | 8.0 | (23) | 1.2 | (57) | 4.6 | 0.50 | 0.50 |
| | 1.64 | 3 | 7.6 | 2.6 | 0.13 | 6.5 | 0.52 | 8.8 | 30 | 1.5 | 74 | 6.0 | 0.65 | 0.35 |
| | 1.44 | 4 | 4.4 | 4.5 | 0.23 | 11 | 0.90 | 9.6 | 47 | 2.4 | 120 | 9.5 | 0.73 | 0.27 |
| | 1.29 | 6 | 1.9 | 10 | 0.52 | 26 | 2.1 | 9.7 | 110 | 5.4 | 260 | 21 | 0.82 | 0.18 |
| | 1.22 | 8 | 1.0 | 20 | 0.99 | 49 | 4.0 | 9.4 | 210 | 11 | 520 | 42 | 0.87 | 0.13 |
| | 1.19 | 10 | 0.67 | 30 | 1.5 | 74 | 6.0 | 9.0 | 330 | 17 | 820 | 66 | 0.89 | 0.11 |
| $AgGaS_2$ (IIa) | 1.66 | 2.94 | 2.8 | 7.0 | 0.35 | 17 | 1.4 | 2.2 | 320 | 16 | 790 | 64 | 0.64 | 0.36 |
| | 1.64 | 3 | 6.3 | 3.2 | 0.16 | 7.9 | 0.64 | 2.2 | 140 | 7.2 | 360 | 29 | 0.65 | 0.35 |
| | 1.44 | 4 | 7.7 | 2.6 | 0.13 | 6.4 | 0.52 | 7.1 | 37 | 1.8 | 91 | 7.3 | 0.73 | 0.27 |
| | 1.29 | 6 | 4.3 | 4.7 | 0.23 | 12 | 0.93 | 9.7 | 48 | 2.4 | 120 | 9.6 | 0.82 | 0.18 |
| | 1.22 | 8 | 2.6 | 7.7 | 0.38 | 19 | 1.5 | 9.9 | 78 | 3.9 | 190 | 16 | 0.87 | 0.13 |
| | 1.19 | 10 | 1.6 | 13 | 0.63 | 31 | 2.5 | 10 | 120 | 6.0 | 290 | 24 | 0.89 | 0.11 |

TABLE VI. (Continued)

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) SRO | $P_t$ (KW) DRO | $P_s$ (KW) SRO | $P_s$ (KW) DRO | A ($cm^2$) x $10^5$ | $P_t/A$ ($MW/cm^2$) SRO | $P_t/A$ ($MW/cm^2$) DRO | $P_s/A$ ($MW/cm^2$) SRO | $P_s/A$ ($MW/cm^2$) DRO | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HgS (I) | 2.12 | 2.12 | 8.5 | (2.4) | 0.12 | (5.8) | 0.47 | 106 | (2.2) | 0.11 | (5.5) | 0.44 | 0.50 | 0.50 |
| | 1.64 | 3 | 7.8 | 2.6 | 0.13 | 6.3 | 0.51 | 101 | 2.5 | 0.13 | 6.3 | 0.51 | 0.65 | 0.35 |
| | 1.44 | 4 | 6.7 | 3.0 | 0.15 | 7.3 | 0.59 | 91 | 3.3 | 0.16 | 8.1 | 0.65 | 0.73 | 0.27 |
| | 1.29 | 6 | 5.1 | 3.9 | 0.20 | 9.7 | 0.79 | 74 | 5.3 | 0.27 | 13 | 1.1 | 0.82 | 0.18 |
| | 1.22 | 8 | 3.9 | 5.1 | 0.25 | 13 | 1.0 | 63 | 8.1 | 0.40 | 20 | 1.6 | 0.87 | 0.13 |
| | 1.19 | 10 | 3.1 | 6.4 | 0.32 | 16 | 1.3 | 56 | 11 | 0.57 | 28 | 2.3 | 0.89 | 0.11 |
| HgS (IIb) | 2.12 | 2.12 | 5.3 | (3.8) | 0.19 | (9.4) | 0.76 | 160 | (2.3) | 0.12 | (5.9) | 0.48 | 0.50 | 0.50 |
| | 1.64 | 3 | 6.3 | 3.2 | 0.16 | 7.8 | 0.64 | 140 | 2.3 | 0.12 | 5.7 | 0.46 | 0.65 | 0.35 |
| | 1.44 | 4 | 6.1 | 3.3 | 0.17 | 8.1 | 0.66 | 115 | 2.9 | 0.14 | 7.1 | 0.58 | 0.73 | 0.27 |
| | 1.29 | 6 | 4.9 | 4.1 | 0.20 | 10 | 0.81 | 87 | 4.7 | 0.24 | 12 | 0.94 | 0.82 | 0.18 |
| | 1.22 | 8 | 3.9 | 5.1 | 0.25 | 13 | 1.0 | 71 | 7.2 | 0.36 | 18 | 1.4 | 0.87 | 0.13 |
| | 1.19 | 10 | 3.1 | 6.4 | 0.32 | 16 | 1.3 | 61 | 10 | 0.52 | 26 | 2.1 | 0.89 | 0.11 |
| $Ag_3AsS_3$ (I) | 2.12 | 2.12 | 4.7 | (4.3) | 0.21 | (11) | 0.85 | 120 | (3.6) | 0.18 | (8.8) | 0.71 | 0.50 | 0.50 |
| | 1.64 | 3 | 4.1 | 4.9 | 0.24 | 12 | 0.98 | 110 | 4.3 | 0.21 | 11 | 0.86 | 0.65 | 0.35 |
| | 1.44 | 4 | 3.2 | 6.2 | 0.31 | 15 | 1.2 | 100 | 5.9 | 0.30 | 15 | 1.2 | 0.73 | 0.27 |
| | 1.29 | 6 | 2.1 | 9.5 | 0.47 | 23 | 1.9 | 86 | 11 | 0.55 | 27 | 2.2 | 0.82 | 0.18 |
| | 1.22 | 8 | 1.5 | 13 | 0.66 | 32 | 2.6 | 74 | 18 | 0.89 | 44 | 3.5 | 0.87 | 0.13 |
| | 1.19 | 10 | 1.1 | 17 | 0.87 | 43 | 3.5 | 65 | 27 | 1.3 | 65 | 5.3 | 0.89 | 0.11 |
| $LiNbO_3$ (I) | 2.12 | 2.12 | 2.0 | (9.8) | 0.49 | (24) | 2.0 | 28 | (35) | 1.8 | (87) | 7.1 | 0.50 | 0.50 |
| | 1.64 | 3 | 1.7 | 12 | 0.58 | 29 | 2.3 | 28 | 42 | 2.1 | 100 | 8.4 | 0.65 | 0.35 |
| | 1.44 | 4 | 1.3 | 15 | 0.76 | 38 | 3.1 | 27 | 56 | 2.8 | 140 | 11 | 0.73 | 0.27 |
| $LiIO_3$ (I) | 2.12 | 2.12 | 0.21 | (94) | 4.7 | (230) | 19 | 35 | (270) | 13 | (670) | 54 | 0.50 | 0.50 |
| | 1.64 | 3 | 0.18 | 110 | 5.6 | 270 | 22 | 36 | 310 | 16 | 770 | 62 | 0.65 | 0.35 |
| | 1.33 | 5.3 | 0.091 | 220 | 11 | 540 | 44 | 44 | 500 | 25 | 1200 | 100 | 0.80 | 0.20 |

TABLE VII. COMPARISON OF PARAMETRIC OSCILLATOR PERFORMANCE OF MATERIALS AT A PUMP WAVELENGTH OF 1.3μm

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) | | $P_s$ (KW) | | A ($cm^2$) x $10^5$ | $P_t/A$ ($MW/cm^2$) | | $P_s/A$ ($MW/cm^2$) | | $\frac{\omega_s}{\omega_p}$ | $\frac{\omega_i}{\omega_p}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SRO | DRO | SRO | DRO | | SRO | DRO | SRO | DRO | | |
| $ZnGeP_2$ (IIb)[2] | 1.55 | 8.12 | 450 | 0.044 | 0.0022 | 0.11 | 0.0088 | 2.0 | 2.1 | 0.11 | 5.3 | 0.43 | 0.84 | 0.16 |
| | 1.49 | 10 | 110 | 0.19 | 0.0094 | 0.47 | 0.038 | 2.0 | 9.2 | 0.46 | 23 | 1.8 | 0.87 | 0.13 |
| $ZnGeP_2$ (I) | 1.65 | 6.09 | 12 | 1.6 | 0.081 | 4.0 | 0.32 | 2.0 | 79 | 3.9 | 190 | 16 | 0.79 | 0.21 |
| | 1.55 | 8 | 92 | 0.22 | 0.011 | 0.53 | 0.043 | 2.0 | 11 | 0.53 | 26 | 2.1 | 0.84 | 0.16 |
| | 1.49 | 10 | 70 | 0.29 | 0.014 | 0.70 | 0.057 | 2.6 | 11 | 0.56 | 28 | 2.2 | 0.87 | 0.13 |
| $AgGaSe_2$ (I) | 1.57 | 7.50 | 180 | 0.11 | 0.0056 | 0.28 | 0.022 | 2.5 | 4.5 | 0.23 | 11 | 0.90 | 0.83 | 0.17 |
| | 1.55 | 8 | 120 | 0.17 | 0.0083 | 0.41 | 0.033 | 2.5 | 6.7 | 0.33 | 16 | 1.3 | 0.84 | 0.16 |
| | 1.49 | 10 | 45 | 0.45 | 0.022 | 1.1 | 0.089 | 2.5 | 18 | 0.90 | 45 | 3.6 | 0.87 | 0.13 |
| $Tl_3AsSe_3$ (I) | 2.60 | 2.60 | 16 | (1.2) | 0.062 | (3.1) | 0.25 | 46 | (2.7) | 0.13 | (6.6) | 0.54 | 0.50 | 0.50 |
| | 2.29 | 3 | 15 | 1.3 | 0.066 | 3.3 | 0.26 | 48 | 2.8 | 0.14 | 6.8 | 0.55 | 0.57 | 0.43 |
| | 1.93 | 4 | 11 | 1.9 | 0.095 | 4.7 | 0.38 | 57 | 3.4 | 0.17 | 8.3 | 0.67 | 0.67 | 0.33 |
| | 1.66 | 6 | 5.6 | 3.6 | 0.18 | 8.8 | 0.72 | 65 | 5.5 | 0.27 | 14 | 1.1 | 0.78 | 0.22 |
| | 1.55 | 8 | 3.6 | 5.6 | 0.28 | 14 | 1.1 | 65 | 8.7 | 0.43 | 21 | 1.7 | 0.84 | 0.16 |
| | 1.49 | 10 | 2.6 | 7.8 | 0.39 | 19 | 1.6 | 61 | 13 | 0.64 | 32 | 2.6 | 0.87 | 0.13 |
| | 1.46 | 12 | 2.0 | 10 | 0.51 | 25 | 2.0 | 57 | 18 | 0.89 | 44 | 3.6 | 0.89 | 0.11 |
| HgS (I) | 2.60 | 2.60 | 9.9 | (2.0) | 0.10 | (5.0) | 0.40 | 74 | (2.7) | 0.14 | (6.7) | 0.54 | 0.50 | 0.50 |
| | 2.29 | 3 | 9.7 | 2.1 | 0.10 | 5.1 | 0.40 | 74 | 2.8 | 0.14 | 6.9 | 0.55 | 0.57 | 0.43 |
| | 1.93 | 4 | 8.6 | 2.3 | 0.12 | 5.7 | 0.46 | 68 | 3.4 | 0.17 | 8.4 | 0.68 | 0.67 | 0.33 |
| | 1.66 | 6 | 6.5 | 3.1 | 0.15 | 7.6 | 0.62 | 57 | 5.4 | 0.27 | 13 | 1.1 | 0.78 | 0.22 |
| | 1.55 | 8 | 4.9 | 4.1 | 0.20 | 10 | 0.82 | 50 | 8.1 | 0.41 | 20 | 1.6 | 0.84 | 0.16 |
| | 1.49 | 10 | 3.8 | 5.3 | 0.26 | 13 | 1.1 | 46 | 12 | 0.58 | 28 | 2.3 | 0.87 | 0.13 |
| HgS (IIb) | 2.60 | 2.60 | 5.7 | (3.5) | 0.18 | (8.7) | 0.70 | 130 | (2.8) | 0.14 | (6.8) | 0.55 | 0.50 | 0.50 |
| | 2.29 | 3 | 6.4 | 3.1 | 0.16 | 7.7 | 0.63 | 120 | 2.7 | 0.14 | 6.7 | 0.55 | 0.57 | 0.43 |
| | 1.93 | 4 | 6.7 | 3.0 | 0.15 | 7.4 | 0.60 | 94 | 3.2 | 0.16 | 7.8 | 0.63 | 0.67 | 0.33 |
| | 1.66 | 6 | 5.7 | 3.5 | 0.17 | 8.6 | 0.70 | 71 | 4.9 | 0.25 | 12 | 0.99 | 0.78 | 0.22 |
| | 1.55 | 8 | 4.6 | 4.4 | 0.22 | 11 | 0.88 | 59 | 7.5 | 0.37 | 18 | 1.5 | 0.84 | 0.16 |
| | 1.49 | 10 | 3.6 | 5.5 | 0.28 | 14 | 1.1 | 52 | 11 | 0.53 | 26 | 2.1 | 0.87 | 0.13 |

TABLE VII. (Continued)

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) SRO | $P_t$ (KW) DRO | $P_s$ (KW) SRO | $P_s$ (KW) DRO | A ($cm^2$) x $10^5$ | $P_t$/A ($MW/cm^2$) SRO | $P_t$/A ($MW/cm^2$) DRO | $P_s$/A ($MW/cm^2$) SRO | $P_s$/A ($MW/cm^2$) DRO | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $AgGaS_2$ (IIa)[2] | 2.60 | 2.60 | 6.8 | (2.9) | 0.15 | (7.3) | 0.59 | 2.7 | (110) | 5.4 | (270) | 22 | 0.50 | 0.50 |
| | 2.29 | 3 | 8.2 | 2.4 | 0.12 | 6.0 | 0.49 | 5.3 | 46 | 2.3 | 110 | 9.2 | 0.57 | 0.43 |
| | 1.93 | 4 | 6.8 | 3.0 | 0.15 | 7.3 | 0.59 | 8.5 | 35 | 1.7 | 86 | 6.9 | 0.67 | 0.33 |
| | 1.66 | 6 | 4.0 | 5.0 | 0.25 | 12 | 1.0 | 9.4 | 53 | 2.7 | 130 | 11 | 0.78 | 0.22 |
| | 1.55 | 8 | 2.4 | 8.3 | 0.42 | 21 | 1.7 | 9.6 | 87 | 4.3 | 210 | 17 | 0.84 | 0.16 |
| | 1.49 | 10 | 1.5 | 13 | 0.66 | 33 | 2.7 | 10 | 130 | 6.5 | 320 | 26 | 0.87 | 0.13 |
| $AgAsS_3$ (I) | 2.60 | 2.60 | 4.2 | (4.8) | 0.24 | (12) | 0.96 | 88 | (5.4) | 0.27 | (13) | 1.1 | 0.50 | 0.50 |
| | 2.29 | 3 | 4.1 | 4.9 | 0.25 | 12 | 0.98 | 87 | 5.6 | 0.28 | 14 | 1.1 | 0.57 | 0.43 |
| | 1.93 | 4 | 3.5 | 5.7 | 0.29 | 14 | 1.1 | 81 | 7.1 | 0.35 | 17 | 1.4 | 0.67 | 0.33 |
| | 1.66 | 6 | 2.4 | 8.3 | 0.41 | 20 | 1.7 | 68 | 12 | 0.61 | 30 | 2.4 | 0.78 | 0.22 |
| | 1.55 | 8 | 1.7 | 11 | 0.57 | 28 | 2.3 | 59 | 19 | 0.97 | 48 | 3.9 | 0.84 | 0.16 |
| | 1.49 | 10 | 1.3 | 15 | 0.75 | 37 | 3.0 | 53 | 28 | 1.4 | 70 | 5.7 | 0.87 | 0.13 |
| $AgGaS_2$ (I) | 2.60 | 2.60 | 4.2 | (4.8) | 0.24 | (12) | 0.95 | 9.4 | 51 | 2.5 | (120) | 10 | 0.50 | 0.50 |
| | 2.29 | 3 | 4.0 | 5.0 | 0.25 | 12 | 1.0 | 9.4 | 53 | 2.7 | 130 | 11 | 0.57 | 0.43 |
| | 1.93 | 4 | 2.9 | 6.8 | 0.34 | 17 | 1.4 | 9.3 | 73 | 3.6 | 180 | 15 | 0.67 | 0.33 |
| | 1.66 | 6 | 1.5 | 13 | 0.65 | 32 | 2.6 | 8.9 | 150 | 7.3 | 360 | 29 | 0.78 | 0.22 |
| | 1.55 | 8 | 0.93 | 22 | 1.1 | 53 | 4.3 | 8.5 | 250 | 13 | 630 | 51 | 0.84 | 0.16 |
| | 1.49 | 10 | 0.62 | 32 | 1.6 | 80 | 6.5 | 8.2 | 390 | 20 | 970 | 79 | 0.87 | 0.13 |
| $Ag_3SbS_3$ (I)[3] | 2.60 | 2.60 | 2.7 | (7.4) | 0.37 | (18) | 1.5 | 48 | (15) | 0.77 | (38) | 3.1 | 0.50 | 0.50 |
| | 2.29 | 3 | 2.6 | 7.8 | 0.39 | 19 | 1.6 | 49 | 16 | 0.80 | 39 | 3.2 | 0.57 | 0.43 |
| | 1.93 | 4 | 2.0 | 10 | 0.51 | 25 | 2.1 | 52 | 20 | 0.99 | 49 | 3.9 | 0.67 | 0.33 |
| | 1.66 | 6 | 1.1 | 18 | 0.88 | 43 | 3.5 | 53 | 33 | 1.7 | 82 | 6.6 | 0.78 | 0.22 |
| | 1.55 | 8 | 0.75 | 27 | 1.3 | 65 | 5.3 | 50 | 53 | 2.6 | 130 | 11 | 0.84 | 0.16 |
| | 1.49 | 10 | 0.55 | 37 | 1.8 | 90 | 7.3 | 47 | 79 | 3.9 | 190 | 16 | 0.87 | 0.13 |
| $LiNbO_3$ (I) | 2.60 | 2.60 | 1.5 | (13) | 0.67 | (33) | 2.7 | 26 | (51) | 2.5 | (125) | 10 | 0.50 | 0.50 |
| | 2.29 | 3 | 1.5 | 14 | 0.69 | 34 | 2.8 | 26 | 52 | 2.6 | 130 | 10 | 0.57 | 0.43 |
| | 1.93 | 4 | 1.2 | 16 | 0.81 | 40 | 3.2 | 25 | 64 | 3.2 | 160 | 13 | 0.67 | 0.33 |
| $LiIO_3$ (I) | 2.60 | 2.60 | 0.15 | (140) | 6.8 | (340) | 27 | 39 | (350) | 17 | (860) | 70 | 0.50 | 0.50 |
| | 2.29 | 3 | 0.14 | 140 | 7.1 | 350 | 28 | 40 | 360 | 18 | 880 | 71 | 0.57 | 0.43 |
| | 1.76 | 5 | 0.090 | 220 | 11 | 550 | 44 | 48 | 460 | 23 | 1100 | 92 | 0.74 | 0.26 |

TABLE VIII. COMPARISON OF PARAMETRIC OSCILLATOR PERFORMANCE OF MATERIALS AT A PUMP WAVELENGTH OF 2.1μm

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) SRO | $P_t$ (KW) DRO | $P_s$ (KW) SRO | $P_s$ (KW) DRO | A ($cm^2$) x $10^5$ | $P_t$/A ($MW/cm^2$) SRO | $P_t$/A ($MW/cm^2$) DRO | $P_s$/A ($MW/cm^2$) SRO | $P_s$/A ($MW/cm^2$) DRO | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $ZnGeP_2$ (IIb) | 3.28 | 5.83 | 374 | 0.054 | 0.0027 | 0.13 | 0.011 | 3.3 | 1.6 | 0.081 | 3.9 | 0.32 | 0.64 | 0.36 |
| | 3.23 | 6 | 306 | 0.065 | 0.0032 | 0.16 | 0.013 | 3.3 | 2.0 | 0.098 | 4.9 | 0.39 | 0.65 | 0.35 |
| | 2.85 | 8 | 96 | 0.21 | 0.010 | 0.51 | 0.042 | 3.3 | 6.3 | 0.31 | 15 | 1.3 | 0.74 | 0.26 |
| | 2.66 | 10 | 56 | 0.35 | 0.018 | 0.88 | 0.072 | 3.3 | 11 | 0.54 | 27 | 2.2 | 0.79 | 0.21 |
| $ZnGeP_2$ (I) | 4.20 | 4.20 | 138 | (0.15) | 0.0072 | (0.36) | 0.029 | 3.3 | (4.4) | 0.22 | (11) | 0.87 | 0.50 | 0.50 |
| | 3.62 | 5 | 131 | 0.15 | 0.0076 | 0.38 | 0.031 | 3.3 | 4.6 | 0.23 | 11 | 0.92 | 0.58 | 0.42 |
| | 3.23 | 6 | 114 | 0.17 | 0.0087 | 0.43 | 0.035 | 3.3 | 5.3 | 0.26 | 13 | 1.1 | 0.65 | 0.35 |
| | 2.85 | 8 | 82 | 0.24 | 0.012 | 0.60 | 0.049 | 3.3 | 7.3 | 0.37 | 18 | 1.5 | 0.74 | 0.26 |
| | 2.66 | 10 | 59 | 0.34 | 0.017 | 0.84 | 0.068 | 3.3 | 10 | 0.51 | 25 | 2.1 | 0.79 | 0.21 |
| CdSe (IIb) | 2.76 | 8.75 | 26 | 0.77 | 0.038 | 1.9 | 0.15 | 4.3 | 18 | 0.90 | 45 | 3.6 | 0.76 | 0.24 |
| | 2.74 | 9 | 23 | 0.85 | 0.042 | 2.1 | 0.17 | 4.3 | 20 | 1.0 | 49 | 4.0 | 0.77 | 0.23 |
| | 2.66 | 10 | 17 | 1.2 | 0.060 | 2.9 | 0.24 | 4.3 | 28 | 1.4 | 69 | 5.6 | 0.79 | 0.21 |
| | 2.55 | 12 | 10 | 1.9 | 0.097 | 4.8 | 0.39 | 4.3 | 46 | 2.3 | 110 | 9.1 | 0.82 | 0.18 |
| $AgGaSe_2$ (I) | 4.20 | 4.20 | 28 | (0.71) | 0.035 | (1.8) | 0.14 | 4.0 | (18) | 0.88 | (44) | 3.5 | 0.50 | 0.50 |
| | 3.62 | 5 | 26 | 0.76 | 0.038 | 1.9 | 0.15 | 4.0 | 19 | 0.95 | 47 | 3.8 | 0.58 | 0.42 |
| | 3.23 | 6 | 22 | 0.92 | 0.046 | 2.3 | 0.18 | 4.0 | 23 | 1.1 | 56 | 4.6 | 0.65 | 0.35 |
| | 2.85 | 8 | 15 | 1.4 | 0.069 | 3.4 | 0.28 | 4.0 | 34 | 1.7 | 85 | 6.9 | 0.74 | 0.26 |
| | 2.66 | 10 | 10 | 1.9 | 0.097 | 4.8 | 0.39 | 4.0 | 49 | 2.4 | 120 | 9.7 | 0.79 | 0.21 |
| | 2.55 | 12 | 7.7 | 2.6 | 0.13 | 6.4 | 0.52 | 4.0 | 65 | 3.2 | 160 | 13 | 0.82 | 0.18 |
| $AgGaSe_2$ (IIa) | 3.50 | 5.25 | 6.4 | 3.1 | 0.16 | 7.7 | 0.62 | 4.0 | 78 | 3.9 | 190 | 16 | 0.60 | 0.40 |
| | 3.23 | 6 | 26 | 0.77 | 0.039 | 1.9 | 0.15 | 4.0 | 19 | 0.96 | 47 | 3.8 | 0.65 | 0.35 |
| | 2.85 | 8 | 25 | 0.82 | 0.041 | 2.0 | 0.16 | 4.0 | 20 | 1.0 | 50 | 4.1 | 0.74 | 0.26 |
| | 2.66 | 10 | 19 | 1.1 | 0.054 | 2.7 | 0.22 | 4.0 | 27 | 1.3 | 66 | 5.4 | 0.79 | 0.21 |
| | 2.55 | 12 | 14 | 1.4 | 0.071 | 3.5 | 0.28 | 4.0 | 35 | 1.8 | 87 | 7.1 | 0.82 | 0.18 |

TABLE VIII. (Continued)

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) | | $P_s$ (KW) | | A ($cm^2$) x $10^5$ | $P_t/A$ ($MW/cm^2$) | | $P_s/A$ ($MW/cm^2$) | | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SRO | DRO | SRO | DRO | | SRO | DRO | SRO | DRO | | |
| HgS(I) | 4.20 | 4.20 | 9.0 | (2.2) | 0.11 | (5.3) | 0.43 | 38 | (5.7) | 0.29 | (14) | 1.1 | 0.50 | 0.50 |
| | 3.62 | 5 | 8.6 | 2.3 | 0.12 | 5.8 | 0.47 | 37 | 6.2 | 0.31 | 15 | 1.2 | 0.58 | 0.42 |
| | 3.23 | 6 | 7.6 | 2.6 | 0.13 | 6.5 | 0.53 | 37 | 7.1 | 0.36 | 18 | 1.4 | 0.65 | 0.35 |
| | 2.85 | 8 | 5.6 | 3.6 | 0.18 | 8.8 | 0.71 | 36 | 9.8 | 0.49 | 24 | 2.0 | 0.74 | 0.26 |
| | 2.66 | 10 | 4.1 | 4.9 | 0.24 | 12 | 0.98 | 36 | 13 | 0.67 | 33 | 2.7 | 0.79 | 0.21 |
| $Tl_3AsSe_3$ (I) | 4.20 | 4.20 | 5.8 | (3.5) | 0.17 | (8.6) | 0.70 | 53 | (6.6) | 0.33 | (16) | 1.3 | 0.50 | 0.50 |
| | 3.62 | 5 | 5.5 | 3.6 | 0.18 | 9.0 | 0.73 | 52 | 7.0 | 0.35 | 17 | 1.4 | 0.58 | 0.42 |
| | 3.23 | 6 | 4.9 | 4.0 | 0.20 | 10 | 0.81 | 50 | 8.1 | 0.40 | 20 | 1.6 | 0.65 | 0.35 |
| | 2.85 | 8 | 3.8 | 5.2 | 0.26 | 13 | 1.0 | 45 | 12 | 0.58 | 28 | 2.3 | 0.74 | 0.26 |
| | 2.66 | 10 | 3.0 | 6.6 | 0.33 | 16 | 1.3 | 41 | 16 | 0.81 | 40 | 3.2 | 0.79 | 0.21 |
| | 2.55 | 12 | 2.5 | 8.1 | 0.41 | 20 | 1.6 | 37 | 22 | 1.1 | 54 | 4.3 | 0.82 | 0.18 |
| $AgGaS_2$ (IIa) | 4.20 | 4.20 | 3.4 | (5.9) | 0.29 | (15) | 1.2 | 8.6 | (68) | 3.4 | 170 | 14 | 0.50 | 0.50 |
| | 3.62 | 5 | 3.2 | 6.3 | 0.32 | 15 | 1.3 | 8.9 | 70 | 3.5 | 170 | 14 | 0.58 | 0.42 |
| | 3.23 | 6 | 2.7 | 7.5 | 0.37 | 18 | 1.5 | 9.1 | 82 | 4.1 | 200 | 16 | 0.65 | 0.35 |
| | 2.85 | 8 | 1.8 | 11 | 0.56 | 27 | 2.2 | 9.6 | 120 | 5.8 | 290 | 23 | 0.74 | 0.26 |
| | 2.66 | 10 | 1.2 | 16 | 0.82 | 40 | 3.3 | 11 | 160 | 7.8 | 390 | 31 | 0.79 | 0.21 |
| $Ag_3AsS_3$ (I) | 4.20 | 4.20 | 3.0 | (6.7) | 0.33 | (16) | 1.3 | 44 | (15) | 0.76 | (37) | 3.0 | 0.50 | 0.50 |
| | 3.62 | 5 | 2.9 | 6.9 | 0.35 | 17 | 1.4 | 43 | [illegible] | 0.80 | 39 | 3.2 | 0.58 | 0.42 |
| | 3.23 | 6 | 2.6 | 7.8 | 0.39 | 19 | 1.6 | 42 | 18 | 0.92 | 45 | 3.7 | 0.65 | 0.35 |
| | 2.85 | 8 | 1.9 | 10 | 0.52 | 26 | 2.1 | 40 | 26 | 1.3 | 64 | 5.2 | 0.74 | 0.26 |
| | 2.65 | 10 | 1.5 | 14 | 0.68 | 34 | 2.7 | 39 | 35 | 1.8 | 87 | 7.0 | 0.79 | 0.21 |
| $Ag_3SbS_3$ (I) | 4.20 | 4.20 | 1.2 | (16) | 0.82 | (40) | 3.3 | 39 | (41) | 2.1 | (100) | 8.3 | 0.50 | 0.50 |
| | 3.62 | 5 | 1.2 | 17 | 0.85 | 42 | 3.4 | 39 | 44 | 2.2 | 110 | 8.8 | 0.58 | 0.42 |
| | 3.23 | 6 | 1.1 | 19 | 0.95 | 47 | 3.8 | 37 | 51 | 2.5 | 130 | 10 | 0.65 | 0.35 |
| | 2.85 | 8 | 0.81 | 25 | 1.2 | 61 | 4.9 | 34 | 72 | 3.6 | 180 | 14 | 0.74 | 0.26 |
| | 2.66 | 10 | 0.62 | 32 | 1.6 | 79 | 6.4 | 32 | 100 | 5.0 | 250 | 20 | 0.79 | 0.21 |

TABLE VIII. (Continued)

| Material | $\lambda_s$ (μm) | $\lambda_i$ (μm) | Gain/Watt (1 cm) x $10^5$ | $P_t$ (KW) | | $P_s$ (KW) | | A ($cm^2$) x $10^5$ | $P_t/A$ ($MW/cm^2$) | | $P_s/A$ ($MW/cm^2$) | | $\omega_s/\omega_p$ | $\omega_i/\omega_p$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SRO | DRO | SRO | DRO | | SRO | DRO | SRO | DRO | | |
| $AgGaS_2$ (I) | 4.20 | 4.20 | 1.1 | (18) | 0.91 | (45) | 3.6 | 7.3 | (250) | 12 | (610) | 50 | 0.50 | 0.50 |
| | 3.62 | 5 | 1.0 | 19 | 0.96 | 47 | 3.8 | 7.3 | 260 | 13 | 640 | 52 | 0.58 | 0.42 |
| | 3.23 | 6 | 0.91 | 22 | 1.1 | 54 | 4.4 | 7.3 | 300 | 15 | 740 | 60 | 0.65 | 0.35 |
| | 2.85 | 8 | 0.67 | 30 | 1.5 | 74 | 5.9 | 7.4 | 400 | 20 | 990 | 81 | 0.74 | 0.26 |
| | 2.66 | 10 | 0.51 | 40 | 2.0 | 98 | 7.9 | 7.6 | 520 | 26 | 1300 | 100 | 0.79 | 0.21 |

The first column in Tables V to VIII identifies the material and the type of phase matching. The second and third columns give the output wavelengths. The fourth column is the gain per watt for a 1 cm thick crystal. The next two columns give the pump power required to reach threshold for singly and doubly resonant oscillators according to the following relationships:[5]

$$(\text{gain/watt}) \times P_t = 2\,\alpha_s \qquad \text{(SRO)} \qquad (3)$$

$$(\text{gain/watt}) \times P_t = \alpha_s \alpha_i \qquad \text{(DRO)} \qquad (4)$$

where $\alpha_s$ and $\alpha_i$ are the single pass power losses at the signal and idler wavelengths, respectively. For the comparison presented in Tables V to VIII, we have assumed values of $\alpha_s = \alpha_i = 0.1$. At degeneracy ($\lambda_s = \lambda_i$), a singly resonant oscillator has the same threshold as a doubly resonant oscillator. Hence, the numbers given in parentheses in the SRO columns are fictitious and should be interpreted as the pump power for an SRO operating near degeneracy.

The next two columns give the pump power required for pump depletion (saturation) according to[5]

$$P_s = (\pi/2)^2 P_t \qquad \text{(SRO)} \qquad (5)$$

$$P_s = 4P_t \qquad \text{(DRO)} \qquad (6)$$

In Equations 5 and 6, it is assumed that the pump pulse length is much greater than the time required to build up the signal from the incoherent background noise. In cases where buildup time is not negligible, the pump powers required for high conversion efficiency depend on the gain per pass and the ratio of pulse length to oscillator cavity round trip time.[6] Since these parameters can vary over wide ranges, the problem of buildup time is

not treated here. However, a good rule of thumb is that a parametric oscillator pumped by pulses shorter than ~100 ns may be expected to be limited by buildup time.

The columns labeled A in Tables V to VIII are the cross-section areas of the Gaussian beams at the cavity confocal point and are given by

$$A = \pi w_o^2 /2 \qquad (7)$$

$$= b_o \lambda_p / (n_s + n_i)$$

where, for a 1 cm crystal,

$$b_o = B^2/2 \qquad B^2 > 2 \qquad (8)$$

$$b_o = 1 \qquad B^2 \leq 2$$

$$B^2 = \pi \rho^2 n_p / 4\lambda_p \qquad (9)$$

In these equations, $w_o$ is the Gaussian beam waist, $\lambda_p$ is the pump wavelength, $n_s$, $n_i$, and $n_p$ are the refractive indices at the signal, idler, and pump wavelengths, and $\rho$ is the walkoff angle. Equations 8 maximize the confocal parameter $b_o$ (and, hence, minimize the power density at the focus) for a given value of the walkoff parameter B. Values of $b_o$ larger than given by Equations 8 are, to a good approximation, offset by a reduction in gain, so the cross-sections in the Tables V to VIII are essentially optimum.

The columns following A give the power densities at threshold and at saturation. The final two columns give the theoretical maximum conversion efficiency at the two output wavelengths.

## SECTION V

## RANKING OF MATERIALS FOR A SPECIFIC APPLICATION

As an example of how the detailed data presented in Section IV can be used, let us consider a specific application, namely, a parametric oscillator with output in the 3-6 μm region, at a prf of 5 kHz in an SRO configuration. To achieve this repetition rate at the power levels needed to drive a parametric oscillator requires either a $Nd^{3+}$ or $Ho^{3+}$ pump laser operating in a Q-switched, cw-pumped mode. To obtain the highest possible average power, the $Nd^{3+}$ laser should operate on the 1.06 μm (1.08 μm) line of YAG:$Nd^{3+}$ ($YAlO_3$:$Nd^{3+}$), rather than at other possible $Nd^{3+}$ wavelengths (0.94 μm, 1.3 μm, etc.). At an average power output of 10 watts $TEM_{oo}$ (a reasonable upper limit for the present state-of-the-art), a train of 100 nsec pulses at 5 kHz will have a peak power per pulse on the order of 20 kW at the 1.06 μm or 1.08 μm pump wavelength. The $Ho^{3+}$ laser operates at 2.1 μm. A reasonable upper limit for state-of-the-art YAG:α-Ho laser output is 2 watts $TEM_{oo}$. Thus, the pump limit is about 4 kW per pulse at the 2.1 μm pump wavelength.

Using the data in Tables VI and VIII, we can rank the parametric oscillator materials in the order of their merit for the application just posed. This ranking is displayed in Tables IX and X. For purposes of ranking materials in Tables IX and X, we have assumed damage threshold power densities of 100 MW/cm$^2$ for $LiNbO_3$ and $LiIO_3$ and 50 MW/cm$^2$ for all other materials.

According to Tables IX and X, HgS and $ZnGeP_2$ are the best materials for pumping at 1.06 and 2.1 μm, respectively. Both materials have peak power and power density requirements well below the upper limits discussed previously. For SRO configurations, $AgGaSe_2$ pumped at 2.1 μm is the only other material

TABLE IX

LIMITATIONS OF MATERIALS FOR 1.06 μm-PUMPED SINGLY RESONANT PARAMETRIC OSCILLATORS OPERATING IN THE 2-6 μm OUTPUT RANGE AT 5 KHz PRF

| Material | Threshold Power Less than 20KW? | Saturation Power Less Than 20 KW? | Threshold Power Density Less Than Damage Threshold? | Saturation Power Density Less Than Damage Threshold? |
|---|---|---|---|---|
| HgS | Yes | Yes | Yes | Yes |
| $Ag_3AsS_3$ | Yes | Yes [a] | Yes | Yes |
| $Ag_3SbS_3$ | Yes | Yes [b] | Yes | Yes [b] |
| $AgGaS_2$ | Yes | Yes | Yes | No |
| $LiNbO_3$ [c] | Yes | No | Yes | Yes [d] |
| $LiIO_3$ [e] | No | No | No | No |

[a] but not beyond ~ 5μm

[b] but not beyond ~ 4μm

[c] limited by absorption to wavelengths shorter than ~ 4.5μm

[d] but not beyond ~ 3μm

[e] limited by absorption to wavelengths shorter than ~ 5.5μm

## TABLE X

## LIMITATIONS OF MATERIALS FOR 2.1 μm-PUMPED SINGLY RESONANT PARAMETRIC OSCILLATORS OPERATING IN THE 3-6 μm OUTPUT RANGE AT 5 KHz PRF

| Material | Threshold Power Less Than 4 KW? | Saturation Power Less Than 4 KW? | Threshold Power Density Less Than Damage Threshold? | Saturation Power Density Less Than Damage Threshold? |
|---|---|---|---|---|
| $ZnGeP_2$ | Yes | Yes | Yes | Yes |
| $AgGaSe_2$ | Yes | Yes | Yes | Yes |
| HgS | Yes | No | Yes | Yes |
| $Tl_3AsSe_3$ | Yes | No | Yes | Yes |
| $Ag_3AsS_3$ | No | No | Yes | Yes |
| $Ag_3SbS_3$ | No | No | Yes | No |
| $AgGaS_2$ | No | No | No | No |

that has saturation power and power density levels within the state-of-the-art. However, most other materials can be used in SRO configurations up to some level between threshold and complete pump depletion. The materials that can be categorically excluded from consideration in SRO configurations are $LiIO_3$ pumped at 1.06 µm and $AgGaS_2$, $Ag_3SbS_3$, and $Ag_3AsS_3$ pumped at 2.1 µm.

# SECTION VI

## SUMMARY AND CONCLUSIONS

In this report, we have reviewed the state-of-the-art of parametric oscillators and mixers, and have provided detailed theoretical performance data on the most promising materials for use in the 2 to 6 and 8 to 12 µm regions, and have performed a critical evaluation of the materials usable in the 2 to 6 µm region. The spectral coverage available from parametric oscillators and mixers has increased dramatically since 1970. This has been made possible by the development of new nonlinear optical materials such as $Ag_3AsS_3$, CdSe, and $AgGaSe_2$. High average powers and conversion efficiencies have yet to be obtained over the entire infrared bands of interest. Substantial improvements in power and efficiency can be made by further development and use of materials such as HgS and $ZnGeP_2$.

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# APPENDIX A

## $Ag_3AsS_3$ (Proustite)

Sellmeier Equation:[48]

$$(n^o)^2 = 7.4822 + \frac{0.4635}{\lambda^2 - 0.1160} - 0.0016\ \lambda^2$$

$$(n^e)^2 = 6.3434 + \frac{0.3352}{\lambda^2 - 0.1117} - 0.0007\ \lambda^2$$

Refractive Index Data:[50,59]

| $\lambda$ (μm) | $\lambda^{-1}$ (μm$^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 0.5876 | 1.7018 | | 2.7896 | |
| 0.6328 | 1.5803 | 3.0190 | 2.7391 | -0.2799 |
| 0.6516 | 1.5347 | 2.9970 | 2.7230 | -0.2740 |
| 0.6678 | 1.4975 | 2.9804 | 2.7094 | -0.2710 |
| 0.6943 | 1.4403 | 2.9550 | 2.6910 | -0.2640 |
| 1.014 | 0.9862 | 2.8264 | 2.5901 | -0.2363 |
| 1.129 | 0.8857 | 2.8067 | 2.5756 | -0.2311 |
| 1.367 | 0.7315 | 2.7833 | 2.5570 | -0.2263 |
| 1.530 | 0.6536 | 2.7728 | 2.5485 | -0.2243 |
| 1.709 | 0.5851 | 2.7654 | 2.5423 | -0.2231 |
| 2.50 | 0.4000 | 2.7478 | 2.5282 | -0.2196 |
| 3.56 | 0.2809 | 2.7379 | 2.5213 | -0.2166 |
| 4.62 | 0.2165 | 2.7318 | 2.5178 | -0.2140 |
| 10.6 | 0.0943 | 2.7030 | 2.5040 | -0.1990 |

## $AgGaS_2$ (Silver Thiogallate)

**Sellmeier Equation:**[40]

$$(n^o)^2 = \text{[illegible]} + \frac{0.2410}{\lambda^2 - 0.0870} - 0.00210\ \lambda^2$$

$$(n^e)^2 = 5.497 + \frac{0.2026}{\lambda^2 - 0.1307} - 0.00233\ \lambda^2$$

**Refractive Index Data:**[39]

| $\lambda$ ($\mu m$) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| .4900 | 2.0488 | 2.7148 | 2.7287 | .0138 |
| .5000 | 2.0000 | 2.6916 | 2.6867 | -.0049 |
| .5250 | 1.9048 | 2.6503 | 2.6239 | -.0264 |
| .5500 | 1.8182 | 2.6190 | 2.5834 | -.0356 |
| .5750 | 1.7391 | 2.5944 | 2.5537 | -.0407 |
| .6000 | 1.6667 | 2.5748 | 2.5303 | -.0444 |
| .6250 | 1.6000 | 2.5577 | 2.5116 | -.0461 |
| .6500 | 1.5385 | 2.5437 | 2.4961 | -.0476 |
| .6750 | 1.4815 | 2.5310 | 2.4824 | -.0486 |
| .7000 | 1.4286 | 2.5205 | 2.4706 | -.0499 |
| .7500 | 1.3333 | 2.5049 | 2.4540 | -.0509 |
| .8000 | 1.2500 | 2.4909 | 2.4395 | -.0514 |
| .8500 | 1.1765 | 2.4802 | 2.4279 | -.0522 |
| .9000 | 1.1111 | 2.4716 | 2.4192 | -.0525 |
| .9500 | 1.0526 | 2.4644 | 2.4118 | -.0526 |
| 1.0000 | 1.0000 | 2.4582 | 2.4053 | -.0529 |
| 1.1000 | .9091 | 2.4486 | 2.3954 | -.0532 |
| 1.2000 | .8333 | 2.4414 | 2.3881 | -.0533 |
| 1.3000 | .7692 | 2.4359 | 2.3819 | -.0540 |
| 1.4000 | .7143 | 2.4315 | 2.3781 | -.0534 |

| λ (μm) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 1.5000 | .6667 | 2.4280 | 2.3745 | -.0535 |
| 1.6000 | .6250 | 2.4252 | 2.3716 | -.0535 |
| 1.8000 | .5556 | 2.4206 | 2.3670 | -.0536 |
| 2.0000 | .5000 | 2.4164 | 2.3637 | -.0527 |
| 2.2000 | .4545 | 2.4142 | 2.3604 | -.0537 |
| 2.4000 | .4167 | 2.4119 | 2.3583 | -.0535 |
| 2.6000 | .3846 | 2.4102 | 2.3567 | -.0535 |
| 2.8000 | .3571 | 2.4094 | 2.3539 | -.0535 |
| 3.0000 | .3333 | 2.4080 | 2.3545 | -.0535 |
| 3.2000 | .3125 | 2.4068 | 2.3534 | -.0534 |
| 3.4000 | .2941 | 2.4062 | 2.3522 | -.0540 |
| 3.6000 | .2778 | 2.4046 | 2.3511 | -.0535 |
| 3.8000 | .2632 | 2.4024 | 2.3491 | -.0533 |
| 4.0000 | .2500 | 2.4024 | 2.3488 | -.0536 |
| 4.5000 | .2222 | 2.4003 | 2.3461 | -.0542 |
| 5.0000 | .2000 | 2.3955 | 2.3419 | -.0536 |
| 5.5000 | .1818 | 2.3938 | 2.3401 | -.0537 |
| 6.0000 | .1667 | 2.3908 | 2.3369 | -.0539 |
| 6.5000 | .1538 | 2.3874 | 2.3334 | -.0540 |
| 7.0000 | .1429 | 2.3827 | 2.3291 | -.0536 |
| 7.5000 | .1333 | 2.3787 | 2.3252 | -.0535 |
| 8.0000 | .1250 | 2.3757 | 2.3219 | -.0538 |
| 8.5000 | .1176 | 2.3699 | 2.3163 | -.0536 |
| 9.0000 | .1111 | 2.3663 | 2.3121 | -.0542 |
| 9.5000 | .1053 | 2.3606 | 2.3064 | -.0542 |
| 10.0000 | .1000 | 2.3548 | 2.3012 | -.0536 |
| 10.5000 | .0952 | 2.3486 | 2.2948 | -.0538 |
| 11.0000 | .0909 | 2.3417 | 2.2880 | -.0537 |
| 11.5000 | .0870 | 2.3329 | 2.2789 | -.0540 |
| 12.0000 | .0833 | 2.3266 | 2.2716 | -.0550 |
| 12.5000 | .0800 | 2.3177 | | |
| 13.0000 | .0769 | 2.3076 | | |

## $AgGaSe_2$

**Sellmeier Equation:**[42]

$$(n^o)^2 = 3.9362 + \frac{2.9113}{1 - \left(\frac{0.38821}{\lambda}\right)^2} + \frac{1.7954}{1 - \left(\frac{40}{\lambda}\right)^2}$$

$$(n^e)^2 = 3.3132 + \frac{3.3616}{1 - \left(\frac{0.38201}{\lambda}\right)^2} + \frac{1.7677}{1 - \left(\frac{40}{\lambda}\right)^2}$$

**Refractive Index Data:**[41]

| $\lambda$ ($\mu m$) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| .7250 | 1.3793 | 2.8452 | 2.8932 | .0480 |
| .7500 | 1.3333 | 2.8191 | 2.8415 | .0224 |
| .8000 | 1.2500 | 2.7849 | 2.7866 | .0017 |
| .8500 | 1.1765 | 2.7598 | 2.7522 | -.0077 |
| .9000 | 1.1111 | 2.7406 | 2.7275 | -.0130 |
| .9500 | 1.0526 | 2.7252 | 2.7085 | -.0167 |
| 1.0000 | 1.0000 | 2.7132 | 2.6934 | -.0198 |
| 1.1000 | .9091 | 2.6942 | 2.6712 | -.0230 |
| 1.2000 | .8333 | 2.6806 | 2.6554 | -.0253 |
| 1.3000 | .7692 | 2.6705 | 2.6438 | -.0267 |
| 1.4000 | .7143 | 2.6624 | 2.6347 | -.0277 |
| 1.6000 | .6250 | 2.6516 | 2.6224 | -.0292 |
| 1.8000 | .5556 | 2.6432 | 2.6131 | -.0301 |
| 2.0000 | .5000 | 2.6376 | 2.6071 | -.0305 |
| 2.2000 | .4545 | 2.6336 | 2.6027 | -.0309 |
| 2.4000 | .4167 | 2.6304 | 2.5992 | -.0313 |
| 2.6000 | .3846 | 2.6286 | 2.5968 | -.0317 |
| 2.8000 | .3571 | 2.6261 | 2.5943 | -.0318 |
| 3.0000 | .3333 | 2.6245 | 2.5925 | -.0320 |
| 3.2000 | .3125 | 2.6231 | 2.5912 | -.0319 |
| 3.4000 | .2941 | 2.6221 | 2.5899 | -.0321 |

| λ (μm) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 3.6000 | .2778 | 2.6213 | 2.5889 | -.0324 |
| 3.8000 | .2632 | 2.6200 | 2.5876 | -.0324 |
| 4.0000 | .2500 | 2.6189 | 2.5863 | -.0325 |
| 4.5000 | .2222 | 2.6166 | 2.5840 | -.0325 |
| 5.0000 | .2000 | 2.6144 | 2.5819 | -.0326 |
| 5.5000 | .1818 | 2.6128 | 2.5800 | -.0328 |
| 6.0000 | .1667 | 2.6113 | 2.5784 | -.0329 |
| 6.5000 | .1538 | 2.6094 | 2.5765 | -.0329 |
| 7.0000 | .1429 | 2.6070 | 2.5743 | -.0327 |
| 7.5000 | .1333 | 2.6049 | 2.5723 | -.0326 |
| 8.0000 | .1250 | 2.6032 | 2.5704 | -.0328 |
| 8.5000 | .1176 | 2.6009 | 2.5681 | -.0329 |
| 9.0000 | .1111 | 2.5988 | 2.5659 | -.0329 |
| 9.5000 | .1053 | 2.5964 | 2.5635 | -.0329 |
| 10.0000 | .1000 | 2.5939 | 2.5608 | -.0331 |
| 10.5000 | .0952 | 2.5917 | 2.5585 | -.0332 |
| 11.0000 | .0909 | 2.5890 | 2.5555 | -.0335 |
| 11.5000 | .0870 | 2.5868 | 2.5536 | -.0332 |
| 12.0000 | .0833 | 2.5837 | 2.5505 | -.0332 |
| 12.5000 | .0800 | 2.5805 | 2.5473 | -.0333 |
| 13.0000 | .0769 | 2.5771 | 2.5439 | -.0331 |
| 13.5000 | .0741 | 2.5731 | 2.5404 | -.0327 |

## $Ag_3SbS_3$ (Pyrargyrite)

**Sellmeier Equation:**[52]

$$(n^o)^2 = 1 + \frac{6.585\,\lambda^2}{\lambda^2 - 0.16} + \frac{0.1133\,\lambda^2}{\lambda^2 - 225}$$

$$(n^e)^2 = 1 + \frac{5.845\,\lambda^2}{\lambda^2 - 0.16} + \frac{0.0202\,\lambda^2}{\lambda^2 - 225}$$

**Refractive Index Data:** Data not tabulated.

## $CdGeAs_2$

**Sellmeier Equation:**[43]

$$(n^o)^2 = 4 + \frac{8.891}{1 - \left(\frac{0.5524}{\lambda}\right)^2} + \frac{1.886}{1 - \left(\frac{36}{\lambda}\right)^2}$$

$$(n^e)^2 = 4 + \frac{9.521}{1 - \left(\frac{0.6847}{\lambda}\right)^2} + \frac{1.909}{1 - \left(\frac{36}{\lambda}\right)^2}$$

**Refractive Index Data:**[44]

| $\lambda$ (μm) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 2.3000 | .4348 | 3.6076 | | |
| 2.4000 | .4167 | 3.5973 | 3.7545 | .1572 |
| 2.5000 | .4000 | 3.5895 | 3.7316 | .1420 |
| 2.6000 | .3846 | 3.5823 | 3.7156 | .1333 |
| 2.7000 | .3704 | 3.5773 | 3.7030 | .1257 |
| 2.8000 | .3571 | 3.5721 | 3.6926 | .1206 |
| 2.9000 | .3448 | 3.5684 | 3.6846 | .1162 |
| 3.0000 | .3333 | 3.5645 | 3.6775 | .1131 |
| 3.1000 | .3226 | 3.5615 | 3.6714 | .1099 |
| 3.2000 | .3125 | 3.5581 | 3.6661 | .1080 |
| 3.4000 | .2941 | 3.5536 | 3.6574 | .1038 |
| 3.6000 | .2778 | 3.5503 | 3.6508 | .1005 |
| 3.8000 | .2632 | 3.5468 | 3.6454 | .0986 |
| 4.0000 | .2500 | 3.5440 | 3.6402 | .0962 |
| 4.2000 | .2381 | 3.5415 | 3.6368 | .0954 |
| 4.4000 | .2273 | 3.5391 | 3.6329 | .0938 |
| 4.6000 | .2174 | 3.5372 | 3.6299 | .0928 |
| 4.8000 | .2083 | 3.5354 | 3.6273 | .0919 |
| 5.0000 | .2000 | 3.5336 | 3.6249 | .0914 |
| 5.5000 | .1818 | 3.5285 | 3.6178 | .0893 |
| 6.0000 | .1667 | 3.5251 | 3.6134 | .0883 |
| 6.5000 | .1538 | 3.5223 | 3.6104 | .0881 |

| $\lambda$ ($\mu m$) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 7.0000 | .1429 | 3.5200 | 3.6073 | .0873 |
| 7.5000 | .1333 | 3.5175 | 3.6050 | .0875 |
| 8.0000 | .1250 | 3.5157 | 3.6030 | .0873 |
| 8.5000 | .1176 | 3.5140 | 3.6009 | .0869 |
| 9.0000 | .1111 | 3.5120 | 3.5988 | .0868 |
| 9.5000 | .1053 | 3.5098 | 3.5966 | .0867 |
| 10.0000 | .1000 | 3.5078 | 3.5942 | .0864 |
| 10.5000 | .0952 | 3.5054 | 3.5922 | .0868 |
| 11.0000 | .0909 | 3.5031 | 3.5896 | .0865 |
| 11.5000 | .0870 | 3.5004 | 3.5871 | .0868 |
| 12.0000 | .0833 | 3.4977 | | |
| 12.5000 | .0800 | 3.4950 | | |

## CdSe

**Sellmeier Equation:**[31]

$$(n^o)^2 = 4.1321 + \frac{1.8587\,\lambda^2}{\lambda^2 - 0.2187} + \frac{3.0461\,\lambda^2}{\lambda^2 - 3380}$$

$$(n^e)^2 = 4.0829 + \frac{2.0038\,\lambda^2}{\lambda^2 - 0.2075} + \frac{3.5540\,\lambda^2}{\lambda^2 - 3629}$$

**Refractive Index Data:**[58]

| $\lambda$ ($\mu m$) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 1.0139 | 0.9863 | 2.5481 | 2.5677 | 0.0196 |
| 1.1287 | 0.8860 | 2.5246 | 2.5444 | 0.0198 |
| 1.3673 | 0.7314 | 2.4971 | 2.5170 | 0.0199 |
| 1.5295 | 0.6538 | 2.4861 | 2.5059 | 0.0198 |
| 1.7109 | 0.5845 | 2.4776 | 2.4974 | 0.0198 |
| 2.3253 | 0.4301 | 2.4627 | 2.4823 | 0.0196 |
| 3.0 | 0.3333 | 2.4553 | 2.4748 | 0.0195 |
| 4.0 | 0.2500 | 2.4500 | 2.4694 | 0.0194 |
| 5.0 | 0.2000 | 2.4464 | 2.4657 | 0.0193 |
| 6.0 | 0.1667 | 2.4434 | 2.4625 | 0.0191 |
| 7.0 | 0.1429 | 2.4398 | 2.4586 | 0.0188 |
| 8.0 | 0.1250 | 2.4367 | 2.4552 | 0.0185 |
| 9.0 | 0.1111 | 2.4333 | 2.4514 | 0.0181 |
| 10.0 | 0.1000 | 2.4294 | 2.4475 | 0.0181 |
| 11.0 | 0.0909 | 2.4252 | 2.4430 | 0.0178 |
| 12.0 | 0.0833 | 2.4204 | 2.4379 | 0.0175 |

## HgS (Cinnabar)

Sellmeier Equation:[48]

$$(n^{o})^2 = 6.9445 + \frac{0.3658}{\lambda^2 - 0.1357} - 0.0019\lambda^2$$

$$(n^{e})^2 = 8.3922 + \frac{0.5390}{\lambda^2 - 0.1388} - 0.0027\lambda^2$$

Refractive Index Data:[47]

| $\lambda$ ($\mu$m) | $\lambda^{-1}$ ($\mu$m$^{-1}$) | $n^e$ | $n^o$ | $n^e - n^o$ |
|---|---|---|---|---|
| 0.62 | 1.6129 | 3.2560 | 2.9028 | 0.3532 |
| 0.65 | 1.5385 | 3.2064 | 2.8655 | 0.3409 |
| 0.68 | 1.4706 | 3.1703 | 2.8384 | 0.3319 |
| 0.70 | 1.4286 | 3.1489 | 2.8224 | 0.3265 |
| 0.80 | 1.2500 | 3.0743 | 2.7704 | 0.3039 |
| 0.90 | 1.1111 | 3.0340 | 2.7387 | 0.2957 |
| 1.00 | 1.0000 | 3.0050 | 2.7120 | 0.2930 |
| 1.20 | 0.8333 | 2.9680 | 2.6884 | 0.2796 |
| 1.40 | 0.7143 | 2.9475 | 2.6730 | 0.2745 |
| 1.60 | 0.6250 | 2.9344 | 2.6633 | 0.2711 |
| 1.80 | 0.5556 | 2.9258 | 2.6567 | 0.2691 |
| 2.00 | 0.5000 | 2.9194 | 2.6518 | 0.2676 |
| 2.20 | 0.4545 | 2.9146 | 2.6483 | 0.2663 |
| 2.40 | 0.4167 | 2.9108 | 2.6455 | 0.2653 |
| 2.60 | 0.3846 | 2.9079 | 2.6433 | 0.2646 |
| 2.80 | 0.3571 | 2.9052 | 2.6414 | 0.2638 |
| 3.00 | 0.3333 | 2.9036 | 2.6401 | 0.2635 |
| 3.20 | 0.3125 | 2.9017 | 2.6387 | 0.2630 |
| 3.40 | 0.294[illegible] | 2.9001 | 2.6375 | 0.2626 |
| 3.60 | 0.2778 | 2.8987 | 2.6358 | 0.2629 |
| 3.80 | 0.2632 | 2.8971 | 2.6353 | 0.2618 |
| 4.00 | 0.2500 | 2.8963 | 2.6348 | 0.2615 |
| 5.00 | 0.2000 | 2.8863 | 2.6267 | 0.2596 |
| 6.00 | 0.1667 | 2.8799 | 2.6233 | 0.2566 |

| $\lambda$ (μm) | $\lambda^{-1}$ (μm$^{-1}$) | $n^e$ | $n^o$ | $n^e - n^o$ |
|---|---|---|---|---|
| 7.00 | 0.1429 | 2.8741 | 2.6156 | 0.2585 |
| 8.00 | 0.1250 | 2.8674 | 2.6112 | 0.2562 |
| 9.00 | 0.1111 | 2.8608 | 2.6066 | 0.2542 |
| 10.00 | 0.1000 | 2.8522 | 2.6018 | 0.2504 |
| 11.00 | 0.0909 | 2.8434 | 2.5914 | 0.2520 |

## $LiIO_3$

**Sellmeier Equation:***

$$(n^{o})^2 = 3.463 + \frac{0.0214}{\lambda^2 - 0.0958} - 0.00677\,\lambda^2$$

$$(n^{e})^2 = 2.961 + \frac{0.0142}{\lambda^2 - 0.0915} - 0.00423\,\lambda^2$$

**Refractive Index Data:**[56,57]

| $\lambda$ ($\mu$m) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^{o}$ | $n^{e}$ | $n^{e} - n^{o}$ |
|---|---|---|---|---|
| 0.400 | 2.500 | 1.948 | 1.780 | -0.168 |
| 0.436 | 2.294 | 1.931 | 1.766 | -0.165 |
| 0.500 | 2.000 | 1.908 | 1.754 | -0.154 |
| 0.530 | 1.887 | 1.901 | 1.750 | -0.151 |
| 0.578 | 1.730 | 1.888 | 1.742 | -0.146 |
| 0.690 | 1.449 | 1.875 | 1.731 | -0.144 |
| 0.800 | 1.250 | 1.868 | 1.724 | -0.144 |
| 1.060 | 0.943 | 1.860 | 1.719 | -0.141 |

*Equation fit to refractive index data and curves in Ref. 56 and 57.

## $LiNbO_3$

Sellmeier Equation:[48]

$$(n^o)^2 = 4.9260 + \frac{0.1170}{\lambda^2 - 0.0473} - 0.0275\,\lambda^2$$

$$(n^e)^2 = 4.5778 + \frac{0.0964}{\lambda^2 - 0.0446} - 0.0221\,\lambda^2$$

Refractive Index Data:[54]

| $\lambda$ (μm) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^e$ | $n^o$ | $n^e - n^o$ |
|---|---|---|---|---|
| 0.42 | 2.3810 | 2.3038 | 2.4144 | -0.1106 |
| 0.45 | 2.2222 | 2.2765 | 2.3814 | -0.1049 |
| 0.50 | 2.0000 | 2.2446 | 2.3444 | -0.0998 |
| 0.55 | 1.8182 | 2.2241 | 2.3188 | -0.0947 |
| 0.60 | 1.6667 | 2.2083 | 2.3002 | -0.0919 |
| 0.65 | 1.5385 | 2.1964 | 2.2862 | -0.0898 |
| 0.70 | 1.4286 | 2.1874 | 2.2756 | -0.0882 |
| 0.80 | 1.2500 | 2.1741 | 2.2598 | -0.0857 |
| 0.90 | 1.1111 | 2.1647 | 2.2487 | -0.0840 |
| 1.00 | 1.0000 | 2.1580 | 2.2407 | -0.0827 |
| 1.20 | 0.8333 | 2.1481 | 2.2291 | -0.0810 |
| 1.40 | 0.7143 | 2.1410 | 2.2208 | -0.0798 |
| 1.60 | 0.6250 | 2.1351 | 2.2139 | -0.0788 |
| 1.80 | 0.5556 | 2.1297 | 2.2074 | -0.0777 |
| 2.00 | 0.5000 | 2.1244 | 2.2015 | -0.0771 |
| 2.20 | 0.4545 | 2.1187 | 2.1948 | -0.0761 |
| 2.40 | 0.4167 | 2.1138 | 2.1882 | -0.0744 |
| 2.60 | 0.3846 | 2.1080 | 2.1814 | -0.0734 |
| 2.80 | 0.3571 | 2.1020 | 2.1741 | -0.0721 |
| 3.00 | 0.3333 | 2.0955 | 2.1663 | -0.0708 |
| 3.20 | 0.3125 | 2.0886 | 2.1580 | -0.0694 |
| 3.40 | 0.2941 | 2.0814 | 2.1493 | -0.0679 |
| 3.60 | 0.2778 | 2.0735 | 2.1398 | -0.0663 |
| 3.80 | 0.2632 | 2.0652 | 2.1299 | -0.0647 |
| 4.00 | 0.2500 | 2.0564 | 2.1193 | -0.0629 |

## $Tl_3AsSe_3$

**Sellmeier Equation:**[55]

$$(n^o)^2 = 1 + \frac{9.977\,\lambda^2}{\lambda^2 - (0.435)^2} + \frac{0.067\,\lambda^2}{\lambda^2 - (20)^2}$$

$$(n^e)^2 = 1 + \frac{8.783\,\lambda^2}{\lambda^2 - (0.435)^2} + \frac{0.051\,\lambda^2}{\lambda^2 - (20)^2}$$

**Refractive Index Data:**[55]

| $\lambda$ ($\mu$m) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 1.553 ± 0.03 | 0.644 | 3.443 | 3.248 | -0.195 |
| 2.66 ± 0.05 | 0.376 | 3.356 | 3.170 | -0.186 |
| 3.29 ± 0.1 | 0.304 | 3.339 | 3.152 | -0.187 |
| 3.365 ± 0.065 | 0.297 | 3.337 | 3.155 | -0.182 |
| 3.38 ± 0.16 | 0.296 | 3.339 | 3.152 | -0.187 |
| 4.35 ± 0.09 | 0.230 | 3.332 | 3.148 | -0.184 |
| 4.46 ± 0.17 | 0.224 | 3.334 | 3.142 | -0.192 |
| 4.55 ± 0.2 | 0.220 | 3.326 | 3.142 | -0.184 |
| 5.26 ± 0.3 | 0.190 | 3.321 | 3.141 | -0.180 |
| 5.3 ± 0.1 | 0.189 | 3.326 | 3.142 | -0.184 |

## $ZnGeP_2$

**Sellmeier Equation:***

$$(n^o)^2 = 9.7497 + \frac{0.6889}{\lambda^2 - 0.1402} - 0.00278\,\lambda^2$$

$$(n^e)^2 = 9.9870 + \frac{0.7451}{\lambda^2 - 0.1489} - 0.00271\,\lambda^2$$

**Refractive Index Data:**[45]

| $\lambda$ ($\mu$m) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 0.64 | 1.5625 | 3.5052 | 3.5802 | 0.0750 |
| 0.66 | 1.5152 | 3.4756 | 3.5467 | 0.0710 |
| 0.68 | 1.4706 | 3.4477 | 3.5160 | 0.0684 |
| 0.70 | 1.4286 | 3.4233 | 3.4885 | 0.0652 |
| 0.75 | 1.3333 | 3.3730 | 3.4324 | 0.0595 |
| 0.80 | 1.2500 | 3.3357 | 3.3915 | 0.0558 |
| 0.85 | 1.1765 | 3.3063 | 3.3593 | 0.0530 |
| 0.90 | 1.1111 | 3.2830 | 3.3336 | 0.0506 |
| 0.95 | 1.0526 | 3.2638 | 3.3124 | 0.0486 |
| 1.00 | 1.0000 | 3.2478 | 3.2954 | 0.0476 |
| 1.10 | 0.9091 | 3.2232 | 3.2688 | 0.0456 |
| 1.20 | 0.8333 | 3.2054 | 3.2493 | 0.0438 |
| 1.30 | 0.7692 | 3.1924 | 3.2346 | 0.0423 |
| 1.40 | 0.7143 | 3.1820 | 3.2244 | 0.0423 |
| 1.60 | 0.6250 | 3.1666 | 3.2077 | 0.0411 |
| 1.80 | 0.5556 | 3.1562 | 3.1965 | 0.0403 |
| 2.00 | 0.5000 | 3.1490 | 3.1889 | 0.0399 |
| 2.20 | 0.4545 | 3.1433 | 3.1829 | 0.0396 |
| 2.40 | 0.4167 | 3.1388 | 3.1780 | 0.0391 |
| 2.60 | 0.3846 | 3.1357 | 3.1745 | 0.0388 |
| 2.80 | 0.3571 | 3.1327 | 3.1717 | 0.0390 |
| 3.00 | 0.3333 | 3.1304 | 3.1693 | 0.0388 |
| 3.20 | 0.3125 | 3.1284 | 3.1671 | 0.0386 |

| $\lambda$ ($\mu m$) | $\lambda^{-1}$ ($\mu m^{-1}$) | $n^o$ | $n^e$ | $n^e - n^o$ |
|---|---|---|---|---|
| 3.40 | 0.2941 | 3.1263 | 3.1647 | 0.0384 |
| 3.60 | 0.2778 | 3.1257 | 3.1632 | 0.0376 |
| 3.80 | 0.2632 | 3.1237 | 3.1616 | 0.0380 |
| 4.00 | 0.2500 | 3.1223 | 3.1608 | 0.0386 |
| 4.20 | 0.2381 | 3.1209 | 3.1595 | 0.0386 |
| 4.50 | 0.2222 | 3.1186 | 3.1561 | 0.0374 |
| 4.70 | 0.2128 | 3.1174 | 3.1549 | 0.0375 |
| 5.00 | 0.2000 | 3.1149 | 3.1533 | 0.0383 |
| 5.50 | 0.1818 | 3.1131 | 3.1518 | 0.0387 |
| 6.00 | 0.1667 | 3.1101 | 3.1480 | 0.0379 |
| 6.50 | 0.1538 | 3.1057 | 3.1445 | 0.0387 |
| 7.00 | 0.1429 | 3.1040 | 3.1420 | 0.0380 |
| 7.50 | 0.1333 | 3.0994 | 3.1378 | 0.0384 |
| 8.00 | 0.1250 | 3.0961 | 3.1350 | 0.0389 |
| 8.50 | 0.1176 | 3.0919 | 3.1311 | 0.0392 |
| 9.00 | 0.1111 | 3.0880 | 3.1272 | 0.0392 |
| 9.50 | 0.1053 | 3.0836 | 3.1231 | 0.0395 |
| 10.00 | 0.1000 | 3.0788 | 3.1183 | 0.0396 |
| 10.50 | 0.0952 | 3.0738 | 3.1137 | 0.0399 |
| 11.00 | 0.0909 | 3.0689 | 3.1087 | 0.0398 |
| 11.50 | 0.0870 | 3.0623 | 3.1008 | 0.0386 |
| 12.00 | 0.0833 | 3.0552 | 3.0949 | 0.0397 |

*Equation fit to refractive index data in Ref. 45.

## APPENDIX B

The calculations presented in this report were carried out on a CDC 6600 computer, using a program called NONLIN. A listing of program NONLIN is given in this Appendix.

Three units must be added to NONLIN in order to perform a calculation. The first unit consists of the index of refraction equations for the material of interest. The indices are defined by the arithmetic function OINDEX (X) and EINDEX (X), when X is wavelength in microns. These two functions are to be inserted before the first executable statement in NONLIN; a pair of comment statements (see lines NON 74 and NON 75) have been included in the program to indicate the correct location for the index functions. (In the actual deck of cards used, this pair of comment cards was of a different color than the rest of the deck to aid in locating them.) A listing of the index of refraction functions for all the materials appearing in Table III is given in Appendix C.

The second unit that must be added to NONLIN is the subroutine DSQUAR. This subroutine is to be inserted immediately after NONLIN. The purpose of DSQUAR, as explained in the comments section of NONLIN, is to compute the square of the effective nonlinear optical coefficient as a function of the phase matching angle Θ. This subroutine will vary depending on the crystallographic point group to which the material of interest belongs. The various DSQUAR subroutines that were used for this report are listed in Appendix D. These subroutines are based on the expressions for $d_{eff}$ (Θ) given in Table III.

The third unit to be added to NONLIN is the input. For the CDC SCOPE System, an end-of-record card (7/8/9 in column 1) must be inserted between subroutine DSQUAR and the input.

As an example of the calculations done for this report, the output generated for cinnabar (HgS, point group 32) is reproduced in Appendix E.

```
      PROGRAM NONLIN(INPUT,OUTPUT,TAPE3=INPUT,TAPE4=OUTPUT)
C
C PROGRAM TO COMPUTE PHASE MATCHING CURVES AND SMALL SIGNAL GAIN FOR
C COLINEAR THREE WAVE OPTICAL PARAMETRIC INTERACTION.  THEORY OF
C CONFOCALLY FOCUSED PHASE MATCHING IS USED (REFERENCES - - G.D. BOYD
C AND D. A. KLEINMAN (B AND K), "PARAMETRIC INTERACTION OF FOCUSED
C GAUSSIAN LIGHT BEAMS", J. APPL. PHYS. VOL. 39,3597(1968), AND S. E.
C HARRIS, "TUNABLE OPTICAL PARAMETRIC OSCILLATORS", IEEE PROC. VOL. 57,
C 2096(1969)). A CRYSTAL THICKNESS OF 1 CM IS ASSUMED.
C
C INPUT - - CARD 1            HEAD            FORMAT(8A10)
C
C                             HEAD            IS ANY 80 COLUMN COMMENT,
C                                             WHICH WILL BE LISTED WITH THE
C                                             OUTPUT.
C
C           CARD 2            IBIF,D          FORMAT(I3,5F10.3)
C
C                             IF(IBIF.LE.0)   THE MATERIAL TO BE PHASE
C                                             MATCHED IS NEGATIVE BIREF.
C                             IF(IBIF.GT.0)   THE MATERIAL IS POSITIVE
C                                             BIREFRINGENT.
C
C                             D               ARE THE ABSOLUTE VALUES OF THE
C                                             NLO COEFFICIENTS IN UNITS OF
C                                             10**12 M/V.
C
C           CARDS 3,4,ETC.  PUMP,CUTOFF       FORMAT(2F10.3)
C
C                             PUMP            IS THE PUMP WAVELENGTH (IN
C                                             MICRONS).
C
C                             CUTOFF          IS THE INFRARED LONG WAVE-
C                                             LENGTH CUTOFF FOR THE IDLER,
C                                             IN MICRONS.  IT IS NEEDED TO
C                                             PREVENT CALCULATION OF
C                                             REFRACTIVE INDICES BEYOND THE
C                                             RANGE OF VALIDITY OF THE INDEX
C                                             EQUATIONS.  AS MANY PUMP
C                                             WAVELENGTHS AS DESIRED MAY BE
C                                             INCLUDED, ONE PER CARD.
C
C THE OUTPUT IS SELF EXPLANATORY.  THETA IS THE P.M. ANGLE, RHO IS THE
C BIREFRINGENCE WALKOFF ANGLE, AND D-EFF IS THE EFFECTIVE NLO
C COEFFICIENT (VARIES WITH THETA).  H(B) IS THE FUNCTION DEFINED BY B
C AND K,(EQ 3.49). THIS FUNCTION TAKES WALKOFF INTO ACCOUNT THROUGH THE
C PARAMETER B, DEFINED BY B AND K (EQ 3.35).  GAIN/WATT (MAX) IS THE
C GAIN/WATT FOR AN INFINITELY THICK, LOSSLESS CRYSTAL.  AREA IS THE
C OPTIMUM BEAM WAIST CROSS SECTION.
C
C THE SUBROUTINE DSQUAR(DSQ,THETAR,I) MUST BE SUPPLIED BY THE USER.  IT
```

```
C RETURNS THE VALUE OF D-EFF (SQUARED) AS A FUNCTION OF THETA, FOR THE
C FOLLOWING CASES - -
C
C           I=0 NEGATIVE BIREF., TYPE  I P.M. (O + O = E)
C           I=1 NEGATIVE BIREF., TYPE II P.M. (O + E = E) OR (E + O = E)
C           I=2 POSITIVE BIREF., TYPE  I P.M. (E + E = O)
C           I=3 POSITIVE BIREF., TYPE II P.M. (O + E = O) OR (E + O = O)
C
C SUBROUTINE DSQUAR MUST ALSO CONTAIN THE FOLLOWING CARD
      COMMON/COEF/D(5)
C
C INSERT BETWEEN THE TWO BLUE COMMENT CARDS BELOW THE FUNCTIONS
C OINDEX(X) AND EINDEX(X), WHERE OINDEX AND EINDEX ARE FUNCTIONS THAT
C CALCULATE THE ORDINARY AND EXTRAORDINARY REFRACTIVE INDICES FOR THE
C MATERIAL AS A FUNCTION OF WAVELENGTH (X = WAVELENGTH IN MICRONS).
C
      DIMENSION HEAD(8)
      REAL IDLER,LHS
      DATA NEG,IPOS,C2,C3/8HNEGATIVE,8HPOSITIVE,1.189815528E-3,
     13.1415926536/
      DATA TA,TB,AA,AB,AC,AD,AE,AF/1H ,1HI,10HO + O = E),10HO + E = E),
     110HE + O = E),10HE + E = O),10HO + E = O),10HE + O = O)/
C INSERT OINDEX(X) AND EINDEX(X) HERE.
C NOW YOU ARE IN BUSINESS.
      C1=180./C3
      READ(3,10) HEAD,IBIF,D
   10 FORMAT(8A10/I3,5F10.3)
      IF(IBIF) 15,15,16
   15 IKIND=NEG
      GO TO 20
   16 IKIND=IPOS
   20 READ(3,25) PUMP,CUTOFF
   25 FORMAT(2F10.3)
      IF(EOF(3)) 26,27
   26 STOP
   27 PRINT 30,HEAD,IKIND,PUMP,D,CUTOFF
   30 FORMAT(1H1,*PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO*/1H0/1H ,
     18A10/1H0/1H ,*PHASE MATCHING FOR *,A8,* BIREFRINGENT CRYSTAL*/1H0,
     2*PUMP WAVELENGTH(MICRONS)=*,F12.3/1H0,*NONLINEAR COEFFICIENTS(X10
     3E12 M/V)=*,5F15.3/1H0,*CUTOFF WAVELENGTH=*,F12.3)
      CUTOFF=1./CUTOFF
      L=0
      I=0
      OMEGAP=1./PUMP
      DEL=OMEGAP/150.
      XO=OINDEX(PUMP)
    31 SIGNAL=2.*PUMP
      OMEGAS=1./SIGNAL
      OMEGAI=OMEGAS
      IDLER=SIGNAL
      IF(L.EQ.0) GO TO 34
      GO TO (112,112,1060,1086),L
```

```
34 IF(IBIF) 35,35,1000
35 XE=EINDEX(PUMP)
   YO=OINDEX(SIGNAL)
   ZZERO=YO
   X=XO*XO-XE*XE
   IF(X) 74,74,40
40 IF(XE.LE.YO) GO TO 65
   PRINT 45,TA,AA,PUMP
45 FORMAT(1H0,*THIS MATERIAL CANNOT BE TYPE I*,A1,2H (,A10,* PHASE MA
  1TCHED FOR THE PUMP WAVELENGTH*,F12.3,* MICRON*)
50 OMEGAS=OMEGAS+DEL
   IF(OMEGAS.GE.OMEGAP) GO TO 100
   OMEGAI=OMEGAP-OMEGAS
   IF(OMEGAI.LT.CUTOFF) GO TO 100
   SIGNAL=1./OMEGAS
   IDLER=1./OMEGAI
   IF(I.EQ.2) GO TO 1005
   YO=OINDEX(SIGNAL)
   ZO=OINDEX(IDLER)
   IF((OMEGAP*XE).GT.(OMEGAS*YO+OMEGAI*ZO)) GO TO 50
   PRINT 60,SIGNAL, IDLER
60 FORMAT(1H ,*IN THE WAVELENGTH REGION*,F12.3,* TO*,F12.3,* MICRON*)
   GO TO 80
74 PRINT 75,IKIND,SIGNAL,IDLER
75 FORMAT(1H0,*THE CALCULATED INDICES FOR THIS MATERIAL DO NOT GIVE *
  1,A8,* BIREFRINGENCE FOR SIGNAL=*,F12.3,* ,IDLER=*,F12.3,* NEXT CAS
  2E*)
   GO TO 110
65 ZO=YO
80 PRINT 91,TA,AA
91 FORMAT(1H0,*RESULTS FOR TYPE I*,A1,2H (,A10,* PHASE MATCHING ARE*/
  11H )
   PRINT 90
90 FORMAT(1H0,*SIGNAL   IDLER      THETA          RHO         THETA      RH
  1O     D-EFF      B          H(B)      GAIN/WATT     GAIN/WATT         ARE
  2A*/1H ,11X,2(8X,5H(RAD)),3X,2(3X,5H(DEG)),2X,9H(*10.E12),24X,
  35H(1CM),8X,5H(MAX),7X,7H(SQ CM)/1H )
85 Y=(OMEGAP*XO/(OMEGAS*YO+OMEGAI*ZO))**2-1.
   SINTH=XE*SQRT(Y/X)
   IF(SINTH.GE.1.) GO TO 1035
   THETAR=ASIN(SINTH)
   SINSQ=SINTH*SINTH
   Y=X*SINSQ+XE*XE
   RHOR=.5*SIN(2.*THETAR)*X/Y
89 Z=XO*XE/SQRT(Y)
88 RHOR=ATAN(RHOR)
   THETAD=C1*THETAR
   RHOD=C1*RHOR
   CALL DSQUAR(DSQ,THETAR,I)
   B=Z*(100.*RHOR)**2/PUMP
   H1=1.068/(1.+1.068*B)
   HM=1./B
```

```
      B=C3*B/4.
      IF(B.LE.2.) GO TO 93
      BJ=B/2.
      GO TO 94
   93 BJ=1.
   94 B=SQRT(B)
      AREA=5.E-5*B0*PUMP/ZZERO
      DEFF=SQRT(DSQ)
      GAIN1=C2*DSQ*PUMP/(SIGNAL*SIGNAL*IDLER*IDLER*Z*Z)
      GAINM=GAIN1*HM
      GAIN1=GAIN1*H1
      PRINT 95,SIGNAL,IDLER,THETAR,RHOR,THETAD,RHOD,DEFF,B,H1,GAIN1,
     1GAINM,AREA
   95 FORMAT(1H ,F5.2,F8.2,1PE13.3,E13.3,0PF9.2, F8.2, F9.2, F9.2,F11.5,
     13(1PE13.3))
   96 OMEGAS=OMEGAS+DEL
      IF(OMEGAS.GE.OMEGAP) GO TO 110
      OMEGAI=OMEGAP-OMEGAS
      IF(OMEGAI.LT.CUTOFF) GO TO 110
      SIGNAL=1./OMEGAS
      IDLER=1./OMEGAI
      YO=OINDEX(SIGNAL)
      ZO=OINDEX(IDLER)
      IF(I.EQ.0) GO TO 85
      GO TO (106,180,1050,1080,1105),L
  100 PRINT 105
  105 FORMAT(1H ,*TYPE II IS ALSO EXCLUDED.*)
      GO TO 20
  106 ZE=EINDEX(IDLER)
      GO TO 135
  110 IF(L.EQ.2) GO TO 20
      IF(I.EQ.0) GO TO 111
      IF(I.EQ.1) GO TO 160
      IF(L-4) 1055,1085,20
  111 L=1
      I=1
      GO TO 31
  112 YO=OINDEX(SIGNAL)
      ZO=YO
      ZE=EINDEX(IDLER)
      IF((YO+ZE).GE.(2.*XE)) GO TO(130,175),L
      GO TO (114,164),L
  114 PRINT 45,TP,AB,PUMP
  120 OMEGAS=OMEGAS+DEL
      IF(OMEGAS.GE.OMEGAP) GO TO 160
      OMEGAI=OMEGAP-OMEGAS
      IF(OMEGAI.LT.CUTOFF) GO TO 160
      SIGNAL=1./OMEGAS
      YO=OINDEX(SIGNAL)
      IDLER=1./OMEGAI
      ZE=EINDEX(IDLER)
      IF((OMEGAS*YO+OMEGAI*ZE).LT.(OMEGAP*XE)) GO TO 120
```

```
      PRINT 60,SIGNAL,IDLER
      ZO=OINDEX(IDLER)
  130 PRINT 91,TB,AB
      PRINT 90
  135 XI=ZO*ZO-ZE*ZE
      IF(XI) 74,74,137
  137 SINSQ=0.
      DEC=.1
  140 LHS=OMEGAS*YO+OMEGAI*ZO*ZE/SQRT(XI*SINSQ+ZE*ZE)
  141 RHS=OMEGAP*XO*XE/SQRT(X*SINSQ+XE*XE)
  142 IF(LHS.GE.RHS) GO TO 150
  145 SINSQ=SINSQ+DEC
      IF(SINSQ.GE.1.) GO TO 1035
      GO TO (140,195,1025),L
  150 IF(DEC.LE.1.E-6) GO TO 155
      SINSQ=SINSQ-DEC
      DEC=.1*DEC
      GO TO 145
  155 THETAR=SQRT(SINSQ)
      THETAR=ASIN(THETAR)
      SIN2=.5*SIN(2.*THETAR)
      IF(L.EQ.3) GO TO 1045
      Y=X*SINSQ+XE*XE
      RP=SIN2*X/Y
      GO TO (156,200),L
  156 YI=XI*SINSQ+ZE*ZE
      RI=SIN2*XI/YI
      RHOR=AMAX1(RP,RI)
      GO TO 89
  160 L=2
      GO TO 31
  164 PRINT 45,TB,AC,PUMP
  170 OMEGAS=OMEGAS+DEL
      IF(OMEGAS.GE.OMEGAP) GO TO 20
      OMEGAI=OMEGAP-OMEGAS
      IF(OMEGAI.LT.CUTOFF) GO TO 20
      SIGNAL=1./OMEGAS
      YE=EINDEX(SIGNAL)
      IDLER=1./OMEGAI
      ZO=OINDEX(IDLER)
      IF((OMEGAS*YE+OMEGAI*ZO).LT.(OMEGAP*XE)) GO TO 170
      PRINT 60,SIGNAL,IDLER
      YO=OINDEX(SIGNAL)
  175 PRINT 91,TB,AC
      PRINT 90
  180 YE=EINDEX(SIGNAL)
      XS=YO*YO-YE*YE
      IF(XS) 74,74,190
  190 SINSQ=0.
      DEC=.1
  195 LHS=OMEGAS*YO*YE/SQRT(XS*SINSQ+YE*YE)+OMEGAI*ZO
      GO TO 141
```

```
 200 YS=XS*SINSQ+YE*YE
     RS=SIN2*XS/YS
     RHOR=AMAX1(RP,RS)
     GO TO 89
1000 I=2
     L=3
     YE=EINDEX(SIGNAL)
     ZZERO=YE
     IF(XO.LE.YE) GO TO 1010
     PRINT 45,TA,AD,PUMP
     GO TO 50
1005 YE=EINDEX(SIGNAL)
     ZE=EINDEX(IDLER)
     IF((OMEGAP*XO).GT.(OMEGAS*YE+OMEGAI*ZE)) GO TO 50
     PRINT 60,SIGNAL,IDLER
     GO TO 1015
1010 ZE=YE
1015 YO=OINDEX(SIGNAL)
     ZO=OINDEX(IDLER)
     PRINT 91,TA,AD
     PRINT 90
1016 XS=YE*YE-YO*YO
     IF(XS) 74,74,1020
1020 XI=ZE*ZE-ZO*ZO
     IF(XI) 74,74,1021
1021 SINSQ=0.
     DEC=.1
1025 LHS=OMEGAS*YO*YE/SQRT(YE*YE-XS*SINSQ)+OMEGAI*ZO*ZE/SQRT(ZE*ZE-
    1 XI*SINSQ)
     RHS=OMEGAP*XO
     GO TO 142
1035 PRINT 1040,SIGNAL,IDLER
1040 FORMAT(1H0,*PHASE MATCHING CUTS OFF AT SIGNAL=*,F12.3,* AND IDLER=
    1*,F12.3)
     GO TO 96
1045 YS=YE*YE-XS*SINSQ
     YI=ZE*ZE-XI*SINSQ
     RS=SIN2*XS/YS
     RI=SIN2*XI/YI
     RHOR=AMAX1(RS,RI)
     Z=XO
     GO TO 88
1050 YE=EINDEX(SIGNAL)
     ZE=EINDEX(IDLER)
     GO TO 1016
1055 I=3
     GO TO 31
1060 L=4
     YO=OINDEX(SIGNAL)
     ZE=EINDEX(IDLER)
     ZO=YO
     IF((YO+ZE).GE.(2.*XO)) GO TO 1070
```

```
      PRINT 45,TB,AE,PUMP
 1065 OMEGAS=OMEGAS+DEL
      IF(OMEGAS.GE.OMEGAP) GO TO 31
      OMEGAI=OMEGAP-OMEGAS
      IF(OMEGAI.LT.CUTOFF) GO TO 31
      SIGNAL=1./OMEGAS
      IDLER=1./OMEGAI
      YO=OINDEX(SIGNAL)
      ZE=EINDEX(IDLER)
      IF((OMEGAS*YO+OMEGAI*ZE).LT.(OMEGAP*XO)) GO TO 1065
      ZO=OINDEX(IDLER)
      PRINT 60,SIGNAL,IDLER
 1070 PRINT 91,TB,AE
      PRINT 90
 1075 XI=ZE*ZE-ZO*ZO
      IF(XI) 74,74,1076
 1076 Y=1.-(OMEGAI*ZO/(OMEGAP*XO-OMEGAS*YO))**2
      SINTH=ZE*SQRT(Y/XI)
      IF(SINTH.GE.1.) GO TO 1035
      THETAR=ASIN(SINTH)
      SINSQ=SINTH*SINTH
      Y=ZE*ZE-XI*SINSQ
      RHOR=.5*SIN(2.*THETAR)*XI/Y
      Z=XO
      GO TO 88
 1080 ZE=EINDEX(IDLER)
      GO TO 1075
 1085 GO TO 31
 1086 L=5
      YE=EINDEX(SIGNAL)
      ZO=OINDEX(IDLER)
      YO=ZO
      IF((YE+ZO).GE.(2.*XO)) GO TO 1095
      PRINT 45,TB,AE,PUMP
 1090 OMEGAS=OMEGAS+DEL
      IF(OMEGAS.GE.OMEGAP) GO TO 20
      OMEGAI=OMEGAP-OMEGAS
      IF(OMEGAI.LT.CUTOFF) GO TO 20
      SIGNAL=1./OMEGAS
      IDLER=1./OMEGAI
      YE=EINDEX(SIGNAL)
      ZO=OINDEX(IDLER)
      IF((OMEGAS*YE+OMEGAI*ZO).LT.(OMEGAP*XO)) GO TO 1090
      YO=OINDEX(SIGNAL)
      PRINT 60,SIGNAL,IDLER
 1095 PRINT 91,TB,AE
      PRINT 90
 1096 XS=YE*YE-YO*YO
      IF(XS) 74,74,1100
 1100 Y=1.-(OMEGAS*YO/(OMEGAP*XO-OMEGAI*ZO))**2
      SINTH=YE*SQRT(Y/XS)
      IF(SINTH.GT.1.) GO TO 1035
```

```
      THETAR=ASIN(SINTH)
      SINSQ=SINTH*SINTH
      Y=YE*YE-XS*SINSQ
      RHOR=.5*SIN(2.*THETAR)*XS/Y
      Z=XO
      GO TO 88
 1105 YE=EINDEX(SIGNAL)
      GO TO 1096
      END
```

APPENDIX C

```
SILVER GALLIUM SULFIDE
      OINDEX(X)=SQRT(5.728+.241 /(X*X-.087 )-.0021 *X*X)
      FINDEX(X)=SQRT(5.497+.2026/(X*X-.1307)-.00233*X*X)

SILVER GALLIUM SELENIDE
      OINDEX(X)=SQRT(3.9362+2.9113*X*X/(X*X-.38821*.38821)+1.7954*X*X/
     1(X*X-1600.))
      EINDEX(X)=SQRT(3.3132+3.3616*X*X/(X*X-.38201*.38201)+1.7677*X*X/
     1(X*X-1600.))

CADMIUM GERMANIUM ARSENIDE
      OINDEX(X)=SQRT(4.+8.891*X*X/(X*X-.5524*.5524)+1.886*X*X/(X*X-1296.
     1))
      FINDEX(X)=SQRT(4.+9.521*X*X/(X*X-.6847*.6847)+1.909*X*X/(X*X-1296.
     1))

ZINC GERMANIUM PHOSPHIDE
      OINDEX(X)=SQRT(9.7497+.6889/(X*X-.1402)-.00278*X*X)
      FINDEX(X)=SQRT(9.957+.7451/(X*X-.1489)-.00271*X*X)

CINNABAR
      OINDEX(X)=SQRT(6.9445+.3658/(X*X-.1357)-.0019*X*X)
      EINDEX(X)=SQRT(8.3922+ .539/(X*X-.1388)-.0027*X*X)

PROUSTITE
      OINDEX(X)=SQRT(7.4822 + .4635/(X*X - .116) - .0016*X*X)
      EINDEX(X)=SQRT( 6.3434 + .3352/(X*X - .1117) - .0007*X*X)

PYRARGYRITE
      OINDEX(X)=SQRT(1.+6.585*X*X/(X*X-.16)+.1133*X*X/(X*X-225.))
      EINDEX(X)=SQRT(1.+5.845*X*X/(X*X-.16)+.0202*X*X/(X*X-225.))

LITHIUM NIOBATE
      OINDEX(X)=SQRT(4.926+.117 /(X*X-.0473)-.0275*X*X)
      EINDEX(X)=SQRT(4.5778+.0964/(X*X-.0446)-.0221*X*X)

THALLIUM ARSENIC SELENIDE
      OINDEX(X)=SQRT(1.+10.125*X*X/(X*X-.445*.445)+.1 *X*X/(X*X-400.))
      FINDEX(X)=SQRT(1.+ 8.93 *X*X/(X*X-.445*.445)+.05*X*X/(X*X-400.))

LITHIUM IODATE
      OINDEX(X)=SQRT(3.467+.0215/(X*X-.0958)-.00677*X*X)
      FINDEX(X)=SQRT(2.961+.0142/(X*X-.0915)-.00423*X*X)

CADMIUM SELENIDE
      OINDEX(X)=SQRT(4.1321+1.8587*X*X/(X*X-.2187)+3.0461*X*X/(X*X-3380.
     1))
      EINDEX(X)=SQRT(4.0829+2.0038*X*X/(X*X-.2075)+3.554 *X*X/(X*X-3629.
     1))
```

# APPENDIX D

```
      SUBROUTINE DSQUAR(DSQ,THETAR,I)
      COMMON/COEF/D(5)
C
C THE FOLLOWING CARDS ARE FOR POINT GROUP 4(BAR)2M. THE COEFFICIENTS
C MUST BE LISTED ON THE INPUT CARD IN THE ORDER D(14), D(36).
C
      SINTH=SIN(THETAR)
      SIN2=SIN(2.*THETAR)
      IF(I.NE.0) GO TO 10
      DSQ=D(2)*D(2)*SINTH*SINTH
      RETURN
   10 IF(I-2) 15,20,25
   15 DSQ=.25*SIN2*SIN2*(D(1)+D(2))**2
      RETURN
   20 DSQ=D(1)*D(1)*SIN2*SIN2
      RETURN
   25 DSQ=D(1)*D(1)*SINTH*SINTH
      RETURN
      END
```

```
      SUBROUTINE DSQUAR(DSQ,THETAR,I)
      COMMON/COEF/D(5)
C
C THE FOLLOWING CARDS ARE FOR POINT GROUP 32 .  THE COEFFICIENTS MUST
C BE LISTED ON THE INPUT CARD IN THE ORDER D(11), D(14).
C
      SINTH=SIN(THETAR)
      COSSQ=1.-SINTH*SINTH
      IF(I.NE.0) GO TO 10
   25 DSQ=D(1)*D(1)*COSSQ
      RETURN
   10 IF(I-2) 15,20,25
   15 SIN2=SIN(2.*THETAR)
      DSQ=(D(1)*COSSQ+.5*D(2)*SIN2)**2
      RETURN
   20 SIN2=SIN(2.*THETAR)
      DSQ=(D(1)*COSSQ+    D(2)*SIN2)**2
      RETURN
      END
```

```
      SUBROUTINE DSQUAR(DSQ,THETAR,I)
      COMMON/COEF/D(5)
C
C THE FOLLOWING CARDS ARE FOR POINT GROUP 3M.  THE COEFFICIENTS MUST
C BE LISTED ON THE INPUT CARD IN THE ORDER D(21), D(31),D(15)
C
      SINSQ=(SIN(THETAR))**2
      COSSQ=1.-SINSQ
      SIN2=SIN(2.*THETAR)
      IF(I.NE.0) GO TO 10
      DSQ=D(1)*D(1)*COSSQ+D(2)*D(2)*SINSQ+D(1)*D(2)*SIN2
      RETURN
   10 IF(I-2) 15,15,20
   15 DSQ=COSSQ*COSSQ*D(1)*D(1)
      RETURN
   20 DSQ=D(3)*D(3)*SINSQ+D(1)*D(1)*COSSQ+D(1)*D(3)*SIN2
      RETURN
      END
```

```
      SUBROUTINE DSQUAR(DSQ,THETAR,I)
      COMMON/COEF/D(5)
C
C THE FOLLOWING CARDS ARE FOR POINT GROUP 6  .  THE COEFFICIENTS MUST
C BE LISTED ON THE INPUT CARD IN THE ORDER D(15), D(31), D(14).
C
      SINTH=SIN(THETAR)
      SIN2=SIN(2.*THETAR)
      IF(I.NE.0) GO TO 10
      DSQ=D(2)*D(2)*SINTH*SINTH
      RETURN
   10 IF(I-2) 15,20,25
   15 DSQ=.25*D(3)*D(3)*SIN2*SIN2
      RETURN
   20 DSQ=    D(3)*D(3)*SIN2*SIN2
      RETURN
   25 DSQ=D(1)*D(1)*SINTH*SINTH
      RETURN
      END
```

```
      SUBROUTINE DSQUAR(DSQ,THETAR,I)
      COMMON/COEF/D(5)
C
C THE FOLLOWING CARDS ARE FOR POINT GROUP 6MM.  THE COEFFICIENTS MUST
C BE LISTED ON THE INPUT CARD IN THE ORDER D(15), D(31).
C
      SINTH=SIN(THETAR)
      IF(I.NE.0) GO TO 10
      DSQ=D(2)*D(2)*SINTH*SINTH
      RETURN
   10 IF(I-2) 15,15,25
   15 DSQ=0.
      RETURN
   25 DSQ=D(1)*D(1)*SINTH*SINTH
      RETURN
      END
```

APPENDIX E

PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO

CINNABAR

PHASE MATCHING FOR POSITIVE BIREFRINGENT CRYSTAL

PUMP WAVELENGTH(MICRONS)= .694

NONLINEAR COEFFICIENTS(X10 E12 M/V)= 50.000 0.000 -0.000 -0.000 -0.000

CUTOFF WAVELENGTH= 30.000

RESULTS FOR TYPE I (E + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.39 | 1.39 | 8.883E-01 | 9.705E-02 | 50.90 | 5.56 | 19.89 | 17.36 | .00260 | 2.858E-05 | 2.865E-05 | 1.775E-03 |
| 1.37 | 1.41 | 8.882E-01 | 9.714E-02 | 50.89 | 5.57 | 19.89 | 17.38 | .00259 | 2.853E-05 | 2.860E-05 | 1.778E-03 |
| 1.35 | 1.43 | 8.879E-01 | 9.724E-02 | 50.87 | 5.57 | 19.91 | 17.40 | .00259 | 2.849E-05 | 2.856E-05 | 1.782E-03 |
| 1.33 | 1.45 | 8.874E-01 | 9.735E-02 | 50.85 | 5.58 | 19.93 | 17.42 | .00258 | 2.845E-05 | 2.852E-05 | 1.786E-03 |
| 1.32 | 1.47 | 8.867E-01 | 9.745E-02 | 50.80 | 5.58 | 19.97 | 17.44 | .00258 | 2.841E-05 | 2.848E-05 | 1.790E-03 |
| 1.30 | 1.49 | 8.858E-01 | 9.757E-02 | 50.75 | 5.59 | 20.01 | 17.46 | .00257 | 2.838E-05 | 2.845E-05 | 1.794E-03 |
| 1.29 | 1.51 | 8.847E-01 | 9.769E-02 | 50.69 | 5.60 | 20.07 | 17.48 | .00256 | 2.836E-05 | 2.843E-05 | 1.798E-03 |
| 1.27 | 1.53 | 8.833E-01 | 9.782E-02 | 50.61 | 5.60 | 20.13 | 17.50 | .00256 | 2.834E-05 | 2.841E-05 | 1.803E-03 |
| 1.25 | 1.55 | 8.818E-01 | 9.795E-02 | 50.52 | 5.61 | 20.21 | 17.52 | .00255 | 2.832E-05 | 2.839E-05 | 1.808E-03 |
| 1.24 | 1.58 | 8.801E-01 | 9.808E-02 | 50.42 | 5.62 | 20.30 | 17.55 | .00254 | 2.831E-05 | 2.838E-05 | 1.813E-03 |
| 1.22 | 1.60 | 8.781E-01 | 9.822E-02 | 50.31 | 5.63 | 20.39 | 17.57 | .00254 | 2.830E-05 | 2.837E-05 | 1.818E-03 |
| 1.21 | 1.63 | 8.760E-01 | 9.836E-02 | 50.19 | 5.64 | 20.50 | 17.60 | .00253 | 2.829E-05 | 2.836E-05 | 1.823E-03 |
| 1.20 | 1.65 | 8.736E-01 | 9.850E-02 | 50.06 | 5.64 | 20.61 | 17.62 | .00252 | 2.829E-05 | 2.836E-05 | 1.828E-03 |
| 1.18 | 1.68 | 8.711E-01 | 9.865E-02 | 49.91 | 5.65 | 20.74 | 17.65 | .00252 | 2.829E-05 | 2.836E-05 | 1.834E-03 |
| 1.17 | 1.71 | 8.683E-01 | 9.880E-02 | 49.75 | 5.66 | 20.87 | 17.68 | .00251 | 2.830E-05 | 2.836E-05 | 1.839E-03 |
| 1.16 | 1.73 | 8.654E-01 | 9.895E-02 | 49.58 | 5.67 | 21.02 | 17.70 | .00250 | 2.830E-05 | 2.837E-05 | 1.845E-03 |
| 1.14 | 1.76 | 8.622E-01 | 9.910E-02 | 49.40 | 5.68 | 21.17 | 17.73 | .00249 | 2.831E-05 | 2.838E-05 | 1.850E-03 |
| 1.13 | 1.79 | 8.589E-01 | 9.924E-02 | 49.21 | 5.69 | 21.34 | 17.76 | .00249 | 2.832E-05 | 2.839E-05 | 1.856E-03 |
| 1.12 | 1.83 | 8.553E-01 | 9.939E-02 | 49.01 | 5.69 | 21.52 | 17.78 | .00248 | 2.833E-05 | 2.839E-05 | 1.861E-03 |
| 1.11 | 1.86 | 8.515E-01 | 9.954E-02 | 48.79 | 5.70 | 21.70 | 17.81 | .00247 | 2.834E-05 | 2.840E-05 | 1.867E-03 |
| 1.10 | 1.89 | 8.476E-01 | 9.969E-02 | 48.56 | 5.71 | 21.90 | 17.83 | .00246 | 2.835E-05 | 2.841E-05 | 1.872E-03 |
| 1.08 | 1.93 | 8.434E-01 | 9.982E-02 | 48.32 | 5.72 | 22.11 | 17.86 | .00246 | 2.835E-05 | 2.842E-05 | 1.877E-03 |
| 1.07 | 1.96 | 8.390E-01 | 9.995E-02 | 48.07 | 5.73 | 22.32 | 17.88 | .00245 | 2.836E-05 | 2.843E-05 | 1.882E-03 |
| 1.06 | 2.00 | 8.345E-01 | 1.001E-01 | 47.81 | 5.73 | 22.55 | 17.91 | .00244 | 2.837E-05 | 2.843E-05 | 1.887E-03 |
| 1.05 | 2.04 | 8.297E-01 | 1.002E-01 | 47.54 | 5.74 | 22.79 | 17.93 | .00244 | 2.837E-05 | 2.843E-05 | 1.892E-03 |
| 1.04 | 2.08 | 8.247E-01 | 1.003E-01 | 47.25 | 5.75 | 23.04 | 17.95 | .00243 | 2.837E-05 | 2.843E-05 | 1.896E-03 |
| 1.03 | 2.12 | 8.196E-01 | 1.004E-01 | 46.96 | 5.75 | 23.29 | 17.96 | .00243 | 2.836E-05 | 2.842E-05 | 1.900E-03 |
| 1.02 | 2.17 | 8.142E-01 | 1.005E-01 | 46.65 | 5.76 | 23.56 | 17.98 | .00242 | 2.835E-05 | 2.841E-05 | 1.903E-03 |
| 1.01 | 2.21 | 8.086E-01 | 1.006E-01 | 46.33 | 5.76 | 23.84 | 17.99 | .00242 | 2.833E-05 | 2.840E-05 | 1.906E-03 |
| 1.00 | 2.26 | 8.028E-01 | 1.006E-01 | 46.00 | 5.77 | 24.13 | 18.01 | .00242 | 2.831E-05 | 2.837E-05 | 1.908E-03 |
| .99 | 2.31 | 7.968E-01 | 1.007E-01 | 45.65 | 5.77 | 24.43 | 18.01 | .00241 | 2.828E-05 | 2.834E-05 | 1.910E-03 |
| .98 | 2.37 | 7.906E-01 | 1.007E-01 | 45.30 | 5.77 | 24.74 | 18.02 | .00241 | 2.824E-05 | 2.830E-05 | 1.911E-03 |
| .97 | 2.42 | 7.842E-01 | 1.007E-01 | 44.93 | 5.77 | 25.06 | 18.02 | .00241 | 2.819E-05 | 2.825E-05 | 1.912E-03 |
| .96 | 2.48 | 7.776E-01 | 1.007E-01 | 44.55 | 5.77 | 25.39 | 18.02 | .00241 | 2.813E-05 | 2.820E-05 | 1.912E-03 |
| .96 | 2.54 | 7.707E-01 | 1.007E-01 | 44.16 | 5.77 | 25.73 | 18.02 | .00241 | 2.836E-05 | 2.813E-05 | 1.910E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .95 | 2.60 | 7.637E-01 | 1.036E-01 | 43.75 | 5.77 | 26.09 | 18.01 | .00242 | 2.798E-05 | 2.804E-05 | 1.908E-03 |
| .94 | 2.67 | 7.564E-01 | 1.036E-01 | 43.34 | 5.76 | 26.45 | 17.99 | .00242 | 2.789E-05 | 2.795E-05 | 1.906E-03 |
| .93 | 2.74 | 7.489E-01 | 1.005E-01 | 42.91 | 5.76 | 26.82 | 17.97 | .00243 | 2.778E-05 | 2.784E-05 | 1.902E-03 |
| .92 | 2.81 | 7.412E-01 | 1.003E-01 | 42.47 | 5.75 | 27.21 | 17.95 | .00243 | 2.766E-05 | 2.772E-05 | 1.897E-03 |
| .91 | 2.89 | 7.333E-01 | 1.002E-01 | 42.01 | 5.74 | 27.60 | 17.92 | .00244 | 2.752E-05 | 2.758E-05 | 1.890E-03 |
| .91 | 2.97 | 7.251E-01 | 9.997E-02 | 41.54 | 5.73 | 28.01 | 17.89 | .00245 | 2.736E-05 | 2.742E-05 | 1.883E-03 |
| .90 | 3.06 | 7.167E-01 | 9.973E-02 | 41.06 | 5.71 | 28.43 | 17.84 | .00246 | 2.718E-05 | 2.724E-05 | 1.874E-03 |
| .89 | 3.15 | 7.080E-01 | 9.946E-02 | 40.57 | 5.70 | 28.85 | 17.80 | .00247 | 2.699E-05 | 2.705E-05 | 1.864E-03 |
| .88 | 3.25 | 6.991E-01 | 9.915E-02 | 40.06 | 5.68 | 29.29 | 17.74 | .00249 | 2.677E-05 | 2.683E-05 | 1.852E-03 |
| .87 | 3.36 | 6.900E-01 | 9.880E-02 | 39.53 | 5.66 | 29.74 | 17.68 | .00251 | 2.653E-05 | 2.659E-05 | 1.839E-03 |
| .87 | 3.47 | 6.806E-01 | 9.839E-02 | 39.00 | 5.64 | 30.20 | 17.60 | .00253 | 2.628E-05 | 2.633E-05 | 1.824E-03 |
| .86 | 3.59 | 6.710E-01 | 9.794E-02 | 38.44 | 5.61 | 30.67 | 17.52 | .00255 | 2.597E-05 | 2.604E-05 | 1.808E-03 |
| .85 | 3.72 | 6.610E-01 | 9.744E-02 | 37.87 | 5.58 | 31.15 | 17.43 | .00258 | 2.566E-05 | 2.572E-05 | 1.789E-03 |
| .85 | 3.86 | 6.508E-01 | 9.688E-02 | 37.29 | 5.55 | 31.65 | 17.33 | .00261 | 2.531E-05 | 2.537E-05 | 1.769E-03 |
| .84 | 4.00 | 6.403E-01 | 9.627E-02 | 36.69 | 5.52 | 32.15 | 17.22 | .00264 | 2.494E-05 | 2.500E-05 | 1.746E-03 |
| .83 | 4.16 | 6.295E-01 | 9.559E-02 | 36.07 | 5.48 | 32.67 | 17.10 | .00268 | 2.453E-05 | 2.459E-05 | 1.722E-03 |
| .83 | 4.34 | 6.184E-01 | 9.484E-02 | 35.43 | 5.43 | 33.19 | 16.97 | .00272 | 2.409E-05 | 2.415E-05 | 1.695E-03 |
| .82 | 4.53 | 6.070E-01 | 9.402E-02 | 34.78 | 5.39 | 33.73 | 16.82 | .00277 | 2.362E-05 | 2.368E-05 | 1.666E-03 |
| .81 | 4.73 | 5.952E-01 | 9.313E-02 | 34.10 | 5.34 | 34.28 | 16.66 | .00282 | 2.311E-05 | 2.317E-05 | 1.634E-03 |
| .81 | 4.96 | 5.831E-01 | 9.216E-02 | 33.41 | 5.28 | 34.84 | 16.49 | .00288 | 2.255E-05 | 2.262E-05 | 1.600E-03 |
| .80 | 5.20 | 5.706E-01 | 9.110E-02 | 32.69 | 5.22 | 35.41 | 16.30 | .00295 | 2.196E-05 | 2.202E-05 | 1.564E-03 |
| .79 | 5.48 | 5.578E-01 | 8.995E-02 | 31.96 | 5.15 | 35.99 | 16.09 | .00302 | 2.133E-05 | 2.139E-05 | 1.524E-03 |
| .79 | 5.78 | 5.445E-01 | 8.870E-02 | 31.20 | 5.08 | 36.59 | 15.87 | .00311 | 2.065E-05 | 2.071E-05 | 1.482E-03 |
| .78 | 6.12 | 5.307E-01 | 8.734E-02 | 30.41 | 5.00 | 37.19 | 15.63 | .00321 | 1.992E-05 | 1.998E-05 | 1.437E-03 |
| .78 | 6.51 | 5.166E-01 | 8.587E-02 | 29.60 | 4.92 | 37.80 | 15.36 | .00332 | 1.915E-05 | 1.921E-05 | 1.389E-03 |
| .77 | 6.94 | 5.019E-01 | 8.428E-02 | 28.76 | 4.83 | 38.43 | 15.08 | .00344 | 1.832E-05 | 1.838E-05 | 1.339E-03 |
| .77 | 7.44 | 4.867E-01 | 8.257E-02 | 27.89 | 4.73 | 39.06 | 14.77 | .00359 | 1.744E-05 | 1.749E-05 | 1.284E-03 |
| .76 | 8.01 | 4.710E-01 | 8.071E-02 | 26.99 | 4.62 | 39.70 | 14.44 | .00375 | 1.649E-05 | 1.655E-05 | 1.227E-03 |
| .75 | 8.67 | 4.547E-01 | 7.870E-02 | 26.05 | 4.51 | 40.36 | 14.08 | .00395 | 1.549E-05 | 1.555E-05 | 1.167E-03 |
| .75 | 9.46 | 4.378E-01 | 7.653E-02 | 25.08 | 4.39 | 41.01 | 13.69 | .00417 | 1.442E-05 | 1.448E-05 | 1.104E-03 |
| .74 | 10.41 | 4.202E-01 | 7.419E-02 | 24.06 | 4.25 | 41.69 | 13.27 | .00444 | 1.328E-05 | 1.334E-05 | 1.037E-03 |
| .74 | 11.57 | 4.020E-01 | 7.168E-02 | 23.03 | 4.11 | 42.35 | 12.82 | .00475 | 1.207E-05 | 1.212E-05 | 9.680E-04 |
| .73 | 13.01 | 3.831E-01 | 6.897E-02 | 21.95 | 3.95 | 43.01 | 12.34 | .00513 | 1.077E-05 | 1.082E-05 | 8.964E-04 |
| .73 | 14.87 | 3.636E-01 | 6.610E-02 | 20.83 | 3.79 | 43.68 | 11.83 | .00559 | 9.384E-06 | 9.433E-06 | 8.231E-04 |
| .72 | 17.35 | 3.438E-01 | 6.307E-02 | 19.70 | 3.61 | 44.32 | 11.28 | .00613 | 7.902E-06 | 7.947E-06 | 7.495E-04 |
| .72 | 20.82 | 3.242E-01 | 6.000E-02 | 18.59 | 3.44 | 44.92 | 10.73 | .00677 | 6.313E-06 | 6.354E-06 | 6.783E-04 |
| .71 | 26.02 | 3.065E-01 | 5.715E-02 | 17.56 | 3.27 | 45.45 | 10.23 | .00746 | 4.618E-06 | 4.650E-06 | 6.154E-04 |

THIS MATERIAL CANNOT BE TYPE II (O + E = O) PHASE MATCHED FOR THE PUMP WAVELENGTH .694 MICRON

THIS MATERIAL CANNOT BE TYPE II (E + O = O) PHASE MATCHED FOR THE PUMP WAVELENGTH .694 MICRON
IN THE WAVELENGTH REGION 1.239 TO 1.577 MICRON

RESULTS FOR TYPE II (E + O = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.24 | 1.58 | 1.461E+00 | 2.377E-02 | 83.69 | 1.36 | 5.50 | 4.25 | .04172 | 3.407E-05 | 3.545E-05 | 1.065E-04 |
| 1.22 | 1.60 | 1.409E+00 | 3.452E-02 | 80.73 | 1.98 | 8.05 | 6.18 | .02020 | 3.518E-05 | 3.586E-05 | 2.245E-04 |
| 1.21 | 1.63 | 1.370E+00 | 4.237E-02 | 78.48 | 2.43 | 9.98 | 7.59 | .01349 | 3.579E-05 | 3.625E-05 | 3.382E-04 |
| 1.20 | 1.65 | 1.337E+00 | 4.874E-02 | 76.60 | 2.79 | 11.53 | 8.72 | .01023 | 3.627E-05 | 3.662E-05 | 4.477E-04 |
| 1.18 | 1.68 | 1.308E+00 | 5.417E-02 | 74.93 | 3.10 | 13.00 | 9.69 | .00830 | 3.669E-05 | 3.698E-05 | 5.530E-04 |
| 1.17 | 1.71 | 1.281E+00 | 5.892E-02 | 73.41 | 3.38 | 14.28 | 10.54 | .00782 | 3.707E-05 | 3.732E-05 | 6.541E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.16 | 1.73 | 1.257E+00 | 6.314E-02 | 72.00 | 3.62 | 15.45 | 11.30 | .00612 | 3.742E-05 | 3.763E-05 | 7.512E-04 |
| 1.14 | 1.76 | 1.234E+00 | 6.694E-02 | 70.69 | 3.84 | 16.54 | 11.98 | .00545 | 3.774E-05 | 3.793E-05 | 8.442E-04 |
| 1.13 | 1.79 | 1.212E+00 | 7.038E-02 | 69.44 | 4.03 | 17.55 | 12.59 | .00493 | 3.803E-05 | 3.821E-05 | 9.333E-04 |
| 1.12 | 1.83 | 1.191E+00 | 7.352E-02 | 68.25 | 4.21 | 18.52 | 13.15 | .00452 | 3.830E-05 | 3.846E-05 | 1.019E-03 |
| 1.11 | 1.86 | 1.171E+00 | 7.643E-02 | 67.12 | 4.38 | 19.44 | 13.67 | .00419 | 3.854E-05 | 3.870E-05 | 1.100E-03 |
| 1.10 | 1.89 | 1.152E+00 | 7.905E-02 | 66.02 | 4.53 | 20.32 | 14.14 | .00391 | 3.876E-05 | 3.891E-05 | 1.177E-03 |
| 1.08 | 1.93 | 1.134E+00 | 8.143E-02 | 64.96 | 4.67 | 21.17 | 14.58 | .00368 | 3.896E-05 | 3.909E-05 | 1.251E-03 |
| 1.07 | 1.96 | 1.116E+00 | 8.373E-02 | 63.93 | 4.80 | 21.98 | 14.98 | .00349 | 3.913E-05 | 3.926E-05 | 1.321E-03 |
| 1.06 | 2.00 | 1.098E+00 | 8.591E-02 | 62.92 | 4.92 | 22.76 | 15.35 | .00332 | 3.927E-05 | 3.939E-05 | 1.387E-03 |
| 1.05 | 2.04 | 1.081E+00 | 8.773E-02 | 61.94 | 5.03 | 23.52 | 15.70 | .00318 | 3.939E-05 | 3.951E-05 | 1.450E-03 |
| 1.04 | 2.08 | 1.064E+00 | 8.943E-02 | 60.98 | 5.13 | 24.26 | 16.01 | .00305 | 3.948E-05 | 3.960E-05 | 1.509E-03 |
| 1.03 | 2.12 | 1.048E+00 | 9.112E-02 | 60.04 | 5.22 | 24.97 | 16.30 | .00295 | 3.955E-05 | 3.966E-05 | 1.565E-03 |
| 1.02 | 2.17 | 1.032E+00 | 9.262E-02 | 59.11 | 5.31 | 25.67 | 16.57 | .00285 | 3.958E-05 | 3.969E-05 | 1.616E-03 |
| 1.01 | 2.21 | 1.016E+00 | 9.400E-02 | 58.20 | 5.39 | 26.35 | 16.82 | .00277 | 3.959E-05 | 3.970E-05 | 1.665E-03 |
| 1.00 | 2.26 | 1.000E+00 | 9.526E-02 | 57.30 | 5.46 | 27.01 | 17.04 | .00270 | 3.957E-05 | 3.967E-05 | 1.710E-03 |
| .99 | 2.31 | 9.846E-01 | 9.640E-02 | 56.42 | 5.52 | 27.66 | 17.25 | .00263 | 3.952E-05 | 3.962E-05 | 1.751E-03 |
| .98 | 2.37 | 9.693E-01 | 9.744E-02 | 55.54 | 5.58 | 28.29 | 17.43 | .00258 | 3.945E-05 | 3.954E-05 | 1.789E-03 |
| .97 | 2.42 | 9.542E-01 | 9.838E-02 | 54.67 | 5.64 | 28.91 | 17.60 | .00253 | 3.934E-05 | 3.943E-05 | 1.824E-03 |
| .96 | 2.48 | 9.391E-01 | 9.921E-02 | 53.81 | 5.68 | 29.52 | 17.75 | .00249 | 3.920E-05 | 3.929E-05 | 1.855E-03 |
| .96 | 2.54 | 9.242E-01 | 9.935E-02 | 52.95 | 5.73 | 30.12 | 17.88 | .00245 | 3.903E-05 | 3.912E-05 | 1.882E-03 |
| .95 | 2.60 | 9.094E-01 | 1.006E-01 | 52.10 | 5.76 | 30.71 | 18.00 | .00242 | 3.882E-05 | 3.891E-05 | 1.907E-03 |
| .94 | 2.67 | 8.946E-01 | 1.011E-01 | 51.26 | 5.80 | 31.29 | 18.10 | .00239 | 3.859E-05 | 3.867E-05 | 1.928E-03 |
| .93 | 2.74 | 8.799E-01 | 1.016E-01 | 50.42 | 5.82 | 31.86 | 18.18 | .00237 | 3.832E-05 | 3.840E-05 | 1.945E-03 |
| .92 | 2.81 | 8.653E-01 | 1.020E-01 | 49.58 | 5.84 | 32.42 | 18.25 | .00235 | 3.801E-05 | 3.810E-05 | 1.959E-03 |
| .91 | 2.89 | 8.507E-01 | 1.023E-01 | 48.74 | 5.86 | 32.97 | 18.30 | .00234 | 3.768E-05 | 3.776E-05 | 1.970E-03 |
| .91 | 2.97 | 8.361E-01 | 1.025E-01 | 47.90 | 5.87 | 33.52 | 18.33 | .00233 | 3.730E-05 | 3.738E-05 | 1.978E-03 |
| .90 | 3.05 | 8.215E-01 | 1.026E-01 | 47.07 | 5.88 | 34.06 | 18.35 | .00233 | 3.690E-05 | 3.698E-05 | 1.982E-03 |
| .89 | 3.15 | 8.069E-01 | 1.026E-01 | 46.23 | 5.88 | 34.59 | 18.36 | .00233 | 3.645E-05 | 3.653E-05 | 1.98[illegible]E-03 |
| .88 | 3.25 | 7.923E-01 | 1.025E-01 | 45.40 | 5.87 | 35.11 | 18.34 | .00233 | 3.597E-05 | 3.605E-05 | 1.981E-03 |
| .87 | 3.36 | 7.777E-01 | 1.024E-01 | 44.55 | 5.87 | 35.63 | 18.32 | .00234 | 3.545E-05 | 3.553E-05 | 1.975E-03 |
| .87 | 3.47 | 7.630E-01 | 1.022E-01 | 43.71 | 5.85 | 36.14 | 18.28 | .00235 | 3.490E-05 | 3.498E-05 | 1.966E-03 |
| .86 | 3.59 | 7.482E-01 | 1.018E-01 | 42.87 | 5.83 | 36.65 | 18.22 | .00236 | 3.431E-05 | 3.438E-05 | 1.954E-03 |
| .85 | 3.72 | 7.334E-01 | 1.014E-01 | 42.02 | 5.81 | 37.15 | 18.15 | .00238 | 3.367E-05 | 3.375E-05 | 1.938E-03 |
| .85 | 3.86 | 7.185E-01 | 1.009E-01 | 41.17 | 5.78 | 37.64 | 18.06 | .00240 | 3.300E-05 | 3.308E-05 | 1.919E-03 |
| .84 | 4.00 | 7.034E-01 | 1.003E-01 | 40.30 | 5.75 | 38.13 | 17.95 | .00243 | 3.229E-05 | 3.237E-05 | 1.897E-03 |
| .83 | 4.16 | 6.883E-01 | 9.966E-02 | 39.44 | 5.71 | 38.62 | 17.83 | .00246 | 3.154E-05 | 3.162E-05 | 1.871E-03 |
| .83 | 4.34 | 6.730E-01 | 9.899E-02 | 38.56 | 5.67 | 39.10 | 17.69 | .00250 | 3.075E-05 | 3.083E-05 | 1.842E-03 |
| .82 | 4.53 | 6.576E-01 | 9.801E-02 | 37.68 | 5.62 | 39.57 | 17.54 | .00255 | 2.992E-05 | 2.999E-05 | 1.810E-03 |
| .81 | 4.73 | 6.420E-01 | 9.704E-02 | 36.78 | 5.56 | 40.05 | 17.36 | .00262 | 2.905E-05 | 2.912E-05 | 1.774E-03 |
| .81 | 4.96 | 6.262E-01 | 9.597E-02 | 35.88 | 5.50 | 40.51 | 17.17 | .00266 | 2.813E-05 | 2.820E-05 | 1.735E-03 |
| .80 | 5.20 | 6.102E-01 | 9.479E-02 | 34.96 | 5.43 | 40.98 | 16.96 | .00272 | 2.717E-05 | 2.[illegible]4E-05 | 1.693E-03 |
| .79 | 5.48 | 5.939E-01 | 9.350E-02 | 34.03 | 5.36 | 41.44 | 16.73 | .00280 | 2.617E-05 | [illegible] | 1.647E-03 |
| .79 | 5.78 | 5.774E-01 | 9.209E-02 | 33.09 | 5.28 | 41.89 | 16.48 | .00289 | 2.512E-05 | [illegible] | 1.598E-03 |
| .78 | 6.12 | 5.607E-01 | 9.057E-02 | 32.12 | 5.19 | 42.35 | 16.20 | .00298 | 2.403E-05 | 2.410E-05 | 1.545E-03 |
| .78 | 6.51 | 5.436E-01 | 8.891E-02 | 31.14 | 5.09 | 42.79 | 15.91 | .00309 | 2.289E-05 | 2.296E-05 | 1.490E-03 |
| .77 | 6.94 | 5.261E-01 | 8.713E-02 | 30.14 | 4.99 | 43.24 | 15.59 | .00322 | 2.171E-05 | 2.177E-05 | 1.430E-03 |
| .77 | 7.44 | 5.083E-01 | 8.521E-02 | 29.12 | 4.88 | 43.68 | 15.25 | .00337 | 2.047E-05 | 2.054E-05 | 1.360E-03 |
| .76 | 8.01 | 4.901E-01 | 8.314E-02 | 28.08 | 4.76 | 44.11 | 14.87 | .00354 | 1.919E-05 | 1.926E-05 | 1.302E-03 |
| .75 | 8.67 | 4.714E-01 | 8.091E-02 | 27.01 | 4.64 | 44.55 | 14.48 | .00373 | 1.786E-05 | 1.792E-05 | 1.239E-03 |
| .75 | 9.46 | 4.523E-01 | 7.852E-02 | 25.91 | 4.50 | 44.97 | 14.05 | .00396 | 1.648E-05 | 1.654E-05 | 1.162E-03 |
| .74 | 10.41 | 4.326E-01 | 7.595E-02 | 24.79 | 4.35 | 45.39 | 13.59 | .00424 | 1.504E-05 | 1.510E-05 | 1.087E-03 |
| .74 | 11.57 | 4.124E-01 | 7.321E-02 | 23.63 | 4.19 | 45.81 | 13.10 | .00456 | 1.354E-05 | 1.359E-05 | 1.018E-03 |
| .73 | 13.01 | 3.917E-01 | 7.028E-02 | 22.44 | 4.03 | 46.21 | 12.57 | .00494 | 1.198E-05 | 1.203E-03 | 9.396E-04 |
| .73 | 14.87 | 3.705E-01 | 6.717E-02 | 21.23 | 3.85 | 46.61 | 12.02 | .00541 | 1.035E-05 | 1.040E-05 | 8.502E-04 |
| .72 | 17.35 | 3.492E-01 | 6.393E-02 | 20.01 | 3.66 | 46.98 | 11.44 | .00597 | 8.645E-06 | 8.693E-06 | 7.701E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .72 | 26.62 | 3.281E-01 | 6.364E-02 | 19.8[illegible] | 3.47 | 47.33 | 10.55 | .00663 | 6.862E-06 | 6.984E-06 | 6.929E-04 |
| .71 | 26.32 | 3.090E-01 | 5.758E-02 | 17.71 | 3.30 | 47.63 | 10.30 | .00735 | 4.998E-06 | 5.832E-06 | 6.247E-04 |

PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO

CINNABAR

PHASE MATCHING FOR POSITIVE BIREFRINGENT CRYSTAL

PUMP WAVELENGTH(MICRONS)= .946

NONLINEAR COEFFICIENTS(X10 E12 M/V)= 50.000 0.000 -0.000 -0.000 -0.000

CUTOFF WAVELENGTH= 30.000

RESULTS FOR TYPE I (E + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.89 | 1.89 | 5.718E-01 | 8.379E-02 | 32.76 | 4.80 | 35.36 | 12.60 | .00492 | 7.280E-05 | 7.314E-05 | 1.286E-03 |
| 1.87 | 1.92 | 5.717E-01 | 8.383E-02 | 32.76 | 4.80 | 35.36 | 12.61 | .00492 | 7.272E-05 | 7.306E-05 | 1.287E-03 |
| 1.84 | 1.94 | 5.716E-01 | 8.385E-02 | 32.75 | 4.80 | 35.37 | 12.61 | .00491 | 7.263E-05 | 7.297E-05 | 1.287E-03 |
| 1.82 | 1.97 | 5.713E-01 | 8.387E-02 | 32.73 | 4.81 | 35.38 | 12.61 | .00491 | 7.253E-05 | 7.286E-05 | 1.288E-03 |
| 1.80 | 2.00 | 5.709E-01 | 8.388E-02 | 32.71 | 4.81 | 35.40 | 12.62 | .00491 | 7.240E-05 | 7.274E-05 | 1.288E-03 |
| 1.77 | 2.03 | 5.704E-01 | 8.388E-02 | 32.68 | 4.81 | 35.42 | 12.62 | .00491 | 7.226E-05 | 7.260E-05 | 1.288E-03 |
| 1.75 | 2.06 | 5.698E-01 | 8.386E-02 | 32.65 | 4.81 | 35.45 | 12.61 | .00491 | 7.211E-05 | 7.244E-05 | 1.288E-03 |
| 1.73 | 2.09 | 5.691E-01 | 8.384E-02 | 32.61 | 4.80 | 35.48 | 12.61 | .00492 | 7.194E-05 | 7.227E-05 | 1.287E-03 |
| 1.71 | 2.12 | 5.683E-01 | 8.381E-02 | 32.56 | 4.80 | 35.52 | 12.61 | .00492 | 7.176E-05 | 7.209E-05 | 1.286E-03 |
| 1.69 | 2.15 | 5.674E-01 | 8.377E-02 | 32.51 | 4.80 | 35.56 | 12.60 | .00492 | 7.155E-05 | 7.189E-05 | 1.285E-03 |
| 1.67 | 2.18 | 5.664E-01 | 8.372E-02 | 32.45 | 4.80 | 35.60 | 12.59 | .00493 | 7.134E-05 | 7.167E-05 | 1.283E-03 |
| 1.65 | 2.22 | 5.652E-01 | 8.366E-02 | 32.39 | 4.79 | 35.66 | 12.58 | .00494 | 7.110E-05 | 7.143E-05 | 1.281E-03 |
| 1.63 | 2.25 | 5.640E-01 | 8.359E-02 | 32.31 | 4.79 | 35.71 | 12.57 | .00495 | 7.085E-05 | 7.116E-05 | 1.279E-03 |
| 1.61 | 2.29 | 5.626E-01 | 8.351E-02 | 32.24 | 4.78 | 35.77 | 12.56 | .00496 | 7.058E-05 | 7.091E-05 | 1.277E-03 |
| 1.59 | 2.33 | 5.612E-01 | 8.342E-02 | 32.15 | 4.78 | 35.84 | 12.55 | .00497 | 7.030E-05 | 7.063E-05 | 1.274E-03 |
| 1.58 | 2.36 | 5.596E-01 | 8.331E-02 | 32.06 | 4.77 | 35.91 | 12.53 | .00498 | 7.000E-05 | 7.033E-05 | 1.271E-03 |
| 1.56 | 2.41 | 5.579E-01 | 8.320E-02 | 31.96 | 4.77 | 35.99 | 12.51 | .00499 | 6.968E-05 | 7.001E-05 | 1.267E-03 |
| 1.54 | 2.45 | 5.561E-01 | 8.308E-02 | 31.86 | 4.76 | 36.07 | 12.50 | .00501 | 6.934E-05 | 6.967E-05 | 1.264E-03 |
| 1.53 | 2.49 | 5.542E-01 | 8.294E-02 | 31.75 | 4.75 | 36.15 | 12.47 | .00502 | 6.899E-05 | 6.931E-05 | 1.259E-03 |
| 1.51 | 2.53 | 5.521E-01 | 8.279E-02 | 31.64 | 4.74 | 36.24 | 12.45 | .00504 | 6.861E-05 | 6.894E-05 | 1.255E-03 |
| 1.49 | 2.58 | 5.500E-01 | 8.263E-02 | 31.51 | 4.73 | 36.34 | 12.43 | .00506 | 6.822E-05 | 6.854E-05 | 1.250E-03 |
| 1.48 | 2.63 | 5.477E-01 | 8.246E-02 | 31.38 | 4.72 | 36.44 | 12.40 | .00508 | 6.780E-05 | 6.813E-05 | 1.245E-03 |
| 1.46 | 2.68 | 5.454E-01 | 8.228E-02 | 31.25 | 4.71 | 36.55 | 12.38 | .00510 | 6.737E-05 | 6.769E-05 | 1.239E-03 |
| 1.45 | 2.73 | 5.429E-01 | 8.208E-02 | 31.10 | 4.70 | 36.66 | 12.35 | .00513 | 6.692E-05 | 6.724E-05 | 1.233E-03 |
| 1.43 | 2.78 | 5.403E-01 | 8.187E-02 | 30.95 | 4.69 | 36.77 | 12.31 | .00515 | 6.644E-05 | 6.676E-05 | 1.227E-03 |
| 1.42 | 2.84 | 5.375E-01 | 8.164E-02 | 30.80 | 4.68 | 36.89 | 12.28 | .00518 | 6.594E-05 | 6.627E-05 | 1.220E-03 |
| 1.40 | 2.90 | 5.347E-01 | 8.141E-02 | 30.63 | 4.66 | 37.02 | 12.24 | .00521 | 6.542E-05 | 6.575E-05 | 1.213E-03 |
| 1.39 | 2.96 | 5.317E-01 | 8.115E-02 | 30.46 | 4.65 | 37.15 | 12.21 | .00525 | 6.488E-05 | 6.520E-05 | 1.206E-03 |
| 1.38 | 3.02 | 5.286E-01 | 8.088E-02 | 30.29 | 4.63 | 37.28 | 12.17 | .00528 | 6.432E-05 | 6.464E-05 | 1.198E-03 |
| 1.36 | 3.08 | 5.254E-01 | 8.061E-02 | 30.10 | 4.62 | 37.42 | 12.12 | .00532 | 6.373E-05 | 6.405E-05 | 1.189E-03 |
| 1.35 | 3.15 | 5.220E-01 | 8.030E-02 | 29.91 | 4.60 | 37.57 | 12.08 | .00536 | 6.312E-05 | 6.343E-05 | 1.181E-03 |
| 1.34 | 3.22 | 5.186E-01 | 7.998E-02 | 29.71 | 4.59 | 37.72 | 12.03 | .00540 | 6.248E-05 | 6.279E-05 | 1.171E-03 |
| 1.33 | 3.30 | 5.150E-01 | 7.965E-02 | 29.51 | 4.56 | 37.87 | 11.98 | .00544 | 6.181E-05 | 6.213E-05 | 1.162E-03 |
| 1.31 | 3.38 | 5.113E-01 | 7.930E-02 | 29.29 | 4.54 | 38.03 | 11.93 | .00549 | 6.112E-05 | 6.143E-05 | 1.151E-03 |
| 1.30 | 3.46 | 5.074E-01 | 7.893E-02 | 29.07 | 4.52 | 38.20 | 11.87 | .00554 | 6.040E-05 | 6.071E-05 | 1.141E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.29 | 3.55 | 5.034E-01 | 7.854E-02 | 28.54 | 4.50 | 38.36 | 11.81 | .00560 | 5.965E-05 | 5.996E-05 | 1.129E-03 |
| 1.28 | 3.64 | 4.993E-01 | 7.813E-02 | 28.61 | 4.48 | 38.54 | 11.75 | .00566 | 5.887E-05 | 5.918E-05 | 1.118E-03 |
| 1.27 | 3.73 | 4.950E-01 | 7.771E-02 | 28.36 | 4.45 | 38.72 | 11.69 | .00572 | 5.806E-05 | 5.838E-05 | 1.106E-03 |
| 1.26 | 3.84 | 4.906E-01 | 7.726E-02 | 28.11 | 4.43 | 38.90 | 11.62 | .00579 | 5.722E-05 | 5.753E-05 | 1.093E-03 |
| 1.24 | 3.94 | 4.861E-01 | 7.679E-02 | 27.85 | 4.40 | 39.09 | 11.55 | .00586 | 5.635E-05 | 5.666E-05 | 1.079E-03 |
| 1.23 | 4.05 | 4.814E-01 | 7.629E-02 | 27.58 | 4.37 | 39.29 | 11.47 | .00593 | 5.545E-05 | 5.576E-05 | 1.064E-03 |
| 1.22 | 4.17 | 4.765E-01 | 7.578E-02 | 27.30 | 4.34 | 39.48 | 11.40 | .00601 | 5.451E-05 | 5.481E-05 | 1.051E-03 |
| 1.21 | 4.30 | 4.715E-01 | 7.523E-02 | 27.02 | 4.31 | 39.68 | 11.32 | .00610 | 5.353E-05 | 5.384E-05 | 1.036E-03 |
| 1.20 | 4.43 | 4.664E-01 | 7.467E-02 | 26.72 | 4.28 | 39.89 | 11.23 | .00619 | 5.252E-05 | 5.283E-05 | 1.021E-03 |
| 1.19 | 4.58 | 4.611E-01 | 7.408E-02 | 26.42 | 4.24 | 40.10 | 11.14 | .00629 | 5.147E-05 | 5.178E-05 | 1.005E-03 |
| 1.18 | 4.73 | 4.556E-01 | 7.346E-02 | 26.11 | 4.21 | 40.32 | 11.05 | .00640 | 5.038E-05 | 5.069E-05 | 9.879E-04 |
| 1.17 | 4.89 | 4.500E-01 | 7.281E-02 | 25.78 | 4.17 | 40.54 | 10.95 | .00651 | 4.925E-05 | 4.956E-05 | 9.706E-04 |
| 1.16 | 5.07 | 4.442E-01 | 7.213E-02 | 25.45 | 4.13 | 40.77 | 10.85 | .00663 | 4.808E-05 | 4.838E-05 | 9.526E-04 |
| 1.15 | 5.26 | 4.382E-01 | 7.142E-02 | 25.11 | 4.09 | 41.00 | 10.74 | .00676 | 4.687E-05 | 4.717E-05 | 9.340E-04 |
| 1.14 | 5.46 | 4.321E-01 | 7.069E-02 | 24.76 | 4.05 | 41.23 | 10.63 | .00690 | 4.561E-05 | 4.591E-05 | 9.140E-04 |
| 1.14 | 5.68 | 4.258E-01 | 6.991E-02 | 24.40 | 4.01 | 41.47 | 10.52 | .00706 | 4.431E-05 | 4.460E-05 | 8.949E-04 |
| 1.13 | 5.91 | 4.193E-01 | 6.911E-02 | 24.03 | 3.96 | 41.71 | 10.39 | .00722 | 4.295E-05 | 4.325E-05 | 8.744E-04 |
| 1.12 | 6.17 | 4.126E-01 | 6.827E-02 | 23.64 | 3.91 | 41.96 | 10.27 | .00740 | 4.155E-05 | 4.184E-05 | 8.533E-04 |
| 1.11 | 6.45 | 4.058E-01 | 6.739E-02 | 23.25 | 3.86 | 42.21 | 10.14 | .00759 | 4.010E-05 | 4.038E-05 | 8.319E-04 |
| 1.10 | 6.76 | 3.987E-01 | 6.648E-02 | 22.85 | 3.81 | 42.46 | 10.00 | .00780 | 3.859E-05 | 3.887E-05 | 8.091E-04 |
| 1.09 | 7.09 | 3.915E-01 | 6.552E-02 | 22.43 | 3.75 | 42.72 | 9.86 | .00803 | 3.702E-05 | 3.730E-05 | 7.861E-04 |
| 1.08 | 7.47 | 3.841E-01 | 6.453E-02 | 22.00 | 3.70 | 42.95 | 9.71 | .00827 | 3.540E-05 | 3.568E-05 | 7.624E-04 |
| 1.08 | 7.88 | 3.764E-01 | 6.350E-02 | 21.57 | 3.64 | 43.24 | 9.55 | .00854 | 3.372E-05 | 3.399E-05 | 7.382E-04 |
| 1.07 | 8.35 | 3.686E-01 | 6.243E-02 | 21.12 | 3.58 | 43.51 | 9.39 | .00884 | 3.197E-05 | 3.224E-05 | 7.139E-04 |
| 1.06 | 8.87 | 3.606E-01 | 6.131E-02 | 20.66 | 3.51 | 43.77 | 9.22 | .00916 | 3.016E-05 | 3.042E-05 | 6.883E-04 |
| 1.05 | 9.46 | 3.525E-01 | 6.016E-02 | 20.19 | 3.45 | 44.04 | 9.05 | .00951 | 2.827E-05 | 2.853E-05 | 6.627E-04 |
| 1.04 | 10.14 | 3.442E-01 | 5.897E-02 | 19.72 | 3.38 | 44.31 | 8.87 | .00989 | 2.632E-05 | 2.656E-05 | 6.367E-04 |
| 1.04 | 10.92 | 3.357E-01 | 5.775E-02 | 19.24 | 3.31 | 44.57 | 8.69 | .01031 | 2.429E-05 | 2.453E-05 | 6.107E-04 |
| 1.03 | 11.82 | 3.273E-01 | 5.651E-02 | 18.75 | 3.24 | 44.83 | 8.50 | .01076 | 2.218E-05 | 2.241E-05 | 5.847E-04 |
| 1.02 | 12.90 | 3.188E-01 | 5.526E-02 | 18.27 | 3.17 | 45.09 | 8.31 | .01125 | 1.999E-05 | 2.021E-05 | 5.590E-04 |
| 1.01 | 14.19 | 3.105E-01 | 5.401E-02 | 17.79 | 3.09 | 45.33 | 8.12 | .01177 | 1.772E-05 | 1.792E-05 | 5.341E-04 |
| 1.01 | 15.77 | 3.026E-01 | 5.281E-02 | 17.34 | 3.03 | 45.56 | 7.94 | .01230 | 1.538E-05 | 1.556E-05 | 5.107E-04 |
| 1.00 | 17.74 | 2.953E-01 | 5.171E-02 | 16.92 | 2.96 | 45.76 | 7.78 | .01283 | 1.296E-05 | 1.312E-05 | 4.895E-04 |
| .99 | 20.27 | 2.893E-01 | 5.080E-02 | 16.58 | 2.91 | 45.93 | 7.64 | .01329 | 1.050E-05 | 1.063E-05 | 4.724E-04 |
| .99 | 23.65 | 2.856E-01 | 5.025E-02 | 16.36 | 2.88 | 46.03 | 7.56 | .01358 | 8.030E-06 | 8.133E-06 | 4.622E-04 |
| .98 | 28.38 | 2.861E-01 | 5.038E-02 | 16.40 | 2.89 | 46.02 | 7.58 | .01351 | 5.621E-06 | 5.693E-06 | 4.647E-04 |

RESULTS FOR TYPE II (O + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | R | H(R) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.89 | 1.89 | 8.493E-01 | 9.605E-02 | 48.66 | 5.50 | 33.03 | 14.45 | .00375 | 4.839E-05 | 4.856E-05 | 1.689E-03 |
| 1.87 | 1.92 | 8.567E-01 | 9.595E-02 | 49.08 | 5.50 | 32.75 | 14.43 | .00376 | 4.766E-05 | 4.783E-05 | 1.686E-03 |
| 1.84 | 1.94 | 8.641E-01 | 9.583E-02 | 49.51 | 5.49 | 32.47 | 14.41 | .00377 | 4.692E-05 | 4.708E-05 | 1.681E-03 |
| 1.82 | 1.97 | 8.715E-01 | 9.568E-02 | 49.93 | 5.48 | 32.18 | 14.39 | .00378 | 4.616E-05 | 4.632E-05 | 1.675E-03 |
| 1.80 | 2.00 | 8.790E-01 | 9.551E-02 | 50.36 | 5.47 | 31.90 | 14.37 | .00379 | 4.539E-05 | 4.555E-05 | 1.670E-03 |
| 1.77 | 2.03 | 8.865E-01 | 9.532E-02 | 50.79 | 5.46 | 31.61 | 14.34 | .00381 | 4.460E-05 | 4.476E-05 | 1.664E-03 |
| 1.75 | 2.06 | 8.940E-01 | 9.511E-02 | 51.22 | 5.45 | 31.31 | 14.31 | .00382 | 4.380E-05 | 4.395E-05 | 1.656E-03 |
| 1.73 | 2.09 | 9.016E-01 | 9.488E-02 | 51.66 | 5.44 | 31.02 | 14.27 | .00384 | 4.298E-05 | 4.314E-05 | 1.648E-03 |
| 1.71 | 2.12 | 9.092E-01 | 9.462E-02 | 52.09 | 5.42 | 30.72 | 14.23 | .00386 | 4.216E-05 | 4.231E-05 | 1.639E-03 |
| 1.69 | 2.15 | 9.169E-01 | 9.434E-02 | 52.53 | 5.41 | 30.41 | 14.19 | .00389 | 4.132E-05 | 4.148E-05 | 1.629E-03 |
| 1.67 | 2.18 | 9.246E-01 | 9.403E-02 | 52.97 | 5.39 | 30.11 | 14.14 | .00391 | 4.048E-05 | 4.063E-05 | 1.619E-03 |
| 1.65 | 2.22 | 9.323E-01 | 9.370E-02 | 53.42 | 5.37 | 29.80 | 14.09 | .00394 | 3.963E-05 | 3.977E-05 | 1.607E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.63 | 2.25 | 9.402E-01 | 9.334E-02 | 53.87 | 5.35 | 29.48 | 14.04 | .00397 | 3.876E-05 | 3.891E-05 | 1.599E-03 |
| 1.61 | 2.29 | 9.480E-01 | 9.296E-02 | 54.32 | 5.33 | 29.16 | 13.98 | .00400 | 3.789E-05 | 3.804E-05 | 1.582E-03 |
| 1.59 | 2.33 | 9.560E-01 | 9.255E-02 | 54.77 | 5.30 | 28.84 | 13.92 | .00404 | 3.702E-05 | 3.716E-05 | 1.568E-03 |
| 1.58 | 2.36 | 9.640E-01 | 9.211E-02 | 55.23 | 5.28 | 28.51 | 13.85 | .00408 | 3.614E-05 | 3.628E-05 | 1.553E-03 |
| 1.56 | 2.41 | 9.720E-01 | 9.164E-02 | 55.69 | 5.25 | 28.18 | 13.78 | .00412 | 3.525E-05 | 3.539E-05 | 1.538E-03 |
| 1.54 | 2.45 | 9.802E-01 | 9.114E-02 | 56.16 | 5.22 | 27.84 | 13.71 | .00416 | 3.436E-05 | 3.450E-05 | 1.521E-03 |
| 1.53 | 2.49 | 9.884E-01 | 9.062E-02 | 56.63 | 5.19 | 27.50 | 13.63 | .00421 | 3.347E-05 | 3.360E-05 | 1.503E-03 |
| 1.51 | 2.53 | 9.967E-01 | 9.036E-02 | 57.11 | 5.16 | 27.15 | 13.55 | .00426 | 3.257E-05 | 3.270E-05 | 1.485E-03 |
| 1.49 | 2.58 | 1.005E+00 | 8.947E-02 | 57.59 | 5.13 | 26.80 | 13.46 | .00432 | 3.167E-05 | 3.180E-05 | 1.466E-03 |
| 1.48 | 2.63 | 1.014E+00 | 8.884E-02 | 58.07 | 5.09 | 26.44 | 13.36 | .00438 | 3.078E-05 | 3.090E-05 | 1.445E-03 |
| 1.46 | 2.68 | 1.022E+00 | 8.819E-02 | 58.57 | 5.05 | 26.08 | 13.26 | .00445 | 2.988E-05 | 3.000E-05 | 1.424E-03 |
| 1.45 | 2.73 | 1.031E+00 | 8.748E-02 | 59.07 | 5.01 | 25.70 | 13.16 | .00452 | 2.898E-05 | 2.910E-05 | 1.401E-03 |
| 1.43 | 2.78 | 1.040E+00 | 8.674E-02 | 59.57 | 4.97 | 25.32 | 13.05 | .00459 | 2.808E-05 | 2.820E-05 | 1.378E-03 |
| 1.42 | 2.84 | 1.049E+00 | 8.596E-02 | 60.09 | 4.93 | 24.94 | 12.93 | .00468 | 2.719E-05 | 2.731E-05 | 1.353E-03 |
| 1.40 | 2.90 | 1.058E+00 | 8.514E-02 | 60.61 | 4.88 | 24.54 | 12.81 | .00477 | 2.630E-05 | 2.641E-05 | 1.327E-03 |
| 1.39 | 2.96 | 1.067E+00 | 8.428E-02 | 61.14 | 4.83 | 24.14 | 12.68 | .00487 | 2.541E-05 | 2.552E-05 | 1.300E-03 |
| 1.38 | 3.02 | 1.076E+00 | 8.336E-02 | 61.68 | 4.78 | 23.72 | 12.54 | .00497 | 2.452E-05 | 2.464E-05 | 1.272E-03 |
| 1.36 | 3.08 | 1.086E+00 | 8.240E-02 | 62.22 | 4.72 | 23.30 | 12.39 | .00509 | 2.364E-05 | 2.376E-05 | 1.243E-03 |
| 1.35 | 3.15 | 1.096E+00 | 8.138E-02 | 62.79 | 4.66 | 22.87 | 12.24 | .00522 | 2.277E-05 | 2.288E-05 | 1.212E-03 |
| 1.34 | 3.22 | 1.106E+00 | 8.030E-02 | 63.36 | 4.60 | 22.42 | 12.08 | .00536 | 2.190E-05 | 2.202E-05 | 1.181E-03 |
| 1.33 | 3.30 | 1.116E+00 | 7.916E-02 | 63.94 | 4.54 | 21.96 | 11.91 | .00551 | 2.105E-05 | 2.115E-05 | 1.147E-03 |
| 1.31 | 3.38 | 1.126E+00 | 7.796E-02 | 64.54 | 4.47 | 21.49 | 11.73 | .00568 | 2.019E-05 | 2.030E-05 | 1.113E-03 |
| 1.30 | 3.46 | 1.137E+00 | 7.668E-02 | 65.16 | 4.39 | 21.01 | 11.53 | .00587 | 1.935E-05 | 1.946E-05 | 1.076E-03 |
| 1.29 | 3.55 | 1.148E+00 | 7.532E-02 | 65.79 | 4.32 | 20.50 | 11.33 | .00608 | 1.852E-05 | 1.862E-05 | 1.039E-03 |
| 1.28 | 3.64 | 1.160E+00 | 7.388E-02 | 66.44 | 4.23 | 19.98 | 11.11 | .00632 | 1.769E-05 | 1.780E-05 | 9.994E-04 |
| 1.27 | 3.73 | 1.171E+00 | 7.235E-02 | 67.12 | 4.15 | 19.44 | 10.88 | .00659 | 1.688E-05 | 1.698E-05 | 9.583E-04 |
| 1.26 | 3.84 | 1.184E+00 | 7.071E-02 | 67.81 | 4.05 | 18.88 | 10.63 | .00690 | 1.608E-05 | 1.618E-05 | 9.153E-04 |
| 1.24 | 3.94 | 1.196E+00 | 6.895E-02 | 68.54 | 3.95 | 18.29 | 10.37 | .00725 | 1.529E-05 | 1.539E-05 | 8.705E-04 |
| 1.23 | 4.05 | 1.209E+00 | 6.707E-02 | 69.29 | 3.84 | 17.68 | 10.09 | .00766 | 1.451E-05 | 1.461E-05 | 8.235E-04 |
| 1.22 | 4.17 | 1.223E+00 | 6.503E-02 | 70.08 | 3.73 | 17.03 | 9.78 | .00815 | 1.374E-05 | 1.385E-05 | 7.743E-04 |
| 1.21 | 4.30 | 1.238E+00 | 6.283E-02 | 70.92 | 3.60 | 16.35 | 9.45 | .00872 | 1.299E-05 | 1.310E-05 | 7.227E-04 |
| 1.20 | 4.43 | 1.253E+00 | 6.043E-02 | 71.80 | 3.46 | 15.62 | 9.09 | .00942 | 1.225E-05 | 1.236E-05 | 6.685E-04 |
| 1.19 | 4.58 | 1.270E+00 | 5.779E-02 | 72.74 | 3.31 | 14.84 | 8.69 | .01029 | 1.153E-05 | 1.164E-05 | 6.115E-04 |
| 1.18 | 4.73 | 1.287E+00 | 5.488E-02 | 73.75 | 3.14 | 13.99 | 8.25 | .01141 | 1.082E-05 | 1.094E-05 | 5.513E-04 |
| 1.17 | 4.89 | 1.306E+00 | 5.161E-02 | 74.85 | 2.96 | 13.07 | 7.76 | .01288 | 1.013E-05 | 1.025E-05 | 4.877E-04 |
| 1.16 | 5.07 | 1.327E+00 | 4.791E-02 | 76.06 | 2.75 | 12.05 | 7.21 | .01491 | 9.443E-06 | 9.577E-06 | 4.203E-04 |
| 1.15 | 5.26 | 1.351E+00 | 4.353E-02 | 77.42 | 2.50 | 10.89 | 6.56 | .01793 | 8.773E-06 | 8.923E-06 | 3.486E-04 |
| 1.14 | 5.46 | 1.379E+00 | 3.854E-02 | 78.99 | 2.21 | 9.55 | 5.80 | .02287 | 8.110E-06 | 8.287E-06 | 2.720E-04 |
| 1.14 | 5.68 | 1.412E+00 | 3.220E-02 | 80.88 | 1.85 | 7.92 | 4.84 | .03246 | 7.437E-06 | 7.670E-06 | 1.899E-04 |
| 1.13 | 5.91 | 1.456E+00 | 2.353E-02 | 83.41 | 1.35 | 5.74 | 3.54 | .05925 | 6.679E-06 | 7.072E-06 | 1.013E-04 |
| 1.12 | 6.17 | 1.545E+00 | 5.392E-03 | 88.50 | .31 | 1.31 | .81 | .56380 | 3.066E-06 | 6.493E-06 | 1.619E-05 |

PHASE MATCHING CUTS OFF AT SIGNAL= 1.109 AND IDLER= 6.450

PHASE MATCHING CUTS OFF AT SIGNAL= 1.100 AND IDLER= 6.757

PHASE MATCHING CUTS OFF AT SIGNAL= 1.092 AND IDLER= 7.095

PHASE MATCHING CUTS OFF AT SIGNAL= 1.083 AND IDLER= 7.468

PHASE MATCHING CUTS OFF AT SIGNAL= 1.075 AND IDLER= 7.383

PHASE MATCHING CUTS OFF AT SIGNAL= 1.067 AND IDLER= 8.347

PHASE MATCHING CUTS OFF AT SIGNAL= 1.059 AND IDLER= 8.869

PHASE MATCHING CUTS OFF AT SIGNAL= 1.051 AND IDLER= 9.460

PHASE MATCHING CUTS OFF AT SIGNAL= 1.043 AND IDLER= 10.136

PHASE MATCHING CUTS OFF AT SIGNAL= 1.036 AND IDLER= 10.915

PHASE MATCHING CUTS OFF AT SIGNAL= 1.028 AND IDLER= 11.825

PHASE MATCHING CUTS OFF AT SIGNAL= 1.021 AND IDLER= 12.900

PHASE MATCHING CUTS OFF AT SIGNAL= 1.014 AND IDLER= 14.190

PHASE MATCHING CUTS OFF AT SIGNAL= 1.006 AND IDLER= 15.767

PHASE MATCHING CUTS OFF AT SIGNAL= .999 AND IDLER= 17.737

PHASE MATCHING CUTS OFF AT SIGNAL= .992 AND IDLER= 20.271

PHASE MATCHING CUTS OFF AT SIGNAL= .985 AND IDLER= 23.650

PHASE MATCHING CUTS OFF AT SIGNAL= .979 AND IDLER= 28.380

RESULTS FOR TYPE II (E + O = O), PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.69 | 1.89 | 8.493E-01 | 9.535E-02 | 48.66 | 5.50 | 33.03 | 14.45 | .00375 | 4.839E-05 | 4.856E-05 | 1.689E-03 |
| 1.87 | 1.92 | 8.419E-01 | 9.614E-02 | 48.24 | 5.51 | 33.30 | 14.46 | .00374 | 4.910E-05 | 4.927E-05 | 1.692E-03 |
| 1.84 | 1.94 | 8.345E-01 | 9.620E-02 | 47.82 | 5.51 | 33.58 | 14.47 | .00374 | 4.979E-05 | 4.997E-05 | 1.694E-03 |
| 1.82 | 1.97 | 8.272E-01 | 9.624E-02 | 47.40 | 5.51 | 33.85 | 14.48 | .00374 | 5.046E-05 | 5.064E-05 | 1.696E-03 |
| 1.80 | 2.00 | 8.199E-01 | 9.626E-02 | 46.98 | 5.52 | 34.11 | 14.48 | .00373 | 5.112E-05 | 5.129E-05 | 1.697E-03 |
| 1.77 | 2.03 | 8.126E-01 | 9.626E-02 | 46.56 | 5.52 | 34.38 | 14.48 | .00373 | 5.175E-05 | 5.193E-05 | 1.697E-03 |
| 1.75 | 2.06 | 8.053E-01 | 9.624E-02 | 46.14 | 5.51 | 34.64 | 14.48 | .00373 | 5.236E-05 | 5.254E-05 | 1.696E-03 |
| 1.73 | 2.09 | 7.980E-01 | 9.621E-02 | 45.72 | 5.51 | 34.91 | 14.47 | .00374 | 5.295E-05 | 5.313E-05 | 1.695E-03 |
| 1.71 | 2.12 | 7.908E-01 | 9.615E-02 | 45.31 | 5.51 | 35.17 | 14.46 | .00374 | 5.351E-05 | 5.370E-05 | 1.693E-03 |
| 1.69 | 2.15 | 7.835E-01 | 9.607E-02 | 44.89 | 5.50 | 35.42 | 14.45 | .00375 | 5.405E-05 | 5.424E-05 | 1.690E-03 |
| 1.67 | 2.18 | 7.762E-01 | 9.597E-02 | 44.48 | 5.50 | 35.68 | 14.44 | .00376 | 5.457E-05 | 5.476E-05 | 1.686E-03 |
| 1.65 | 2.22 | 7.690E-01 | 9.586E-02 | 44.06 | 5.49 | 35.93 | 14.42 | .00376 | 5.506E-05 | 5.525E-05 | 1.682E-03 |
| 1.63 | 2.25 | 7.617E-01 | 9.572E-02 | 43.64 | 5.48 | 36.18 | 14.40 | .00378 | 5.552E-05 | 5.572E-05 | 1.678E-03 |
| 1.61 | 2.29 | 7.545E-01 | 9.557E-02 | 43.23 | 5.48 | 36.43 | 14.37 | .00379 | 5.596E-05 | 5.616E-05 | 1.672E-03 |
| 1.59 | 2.33 | 7.472E-01 | 9.540E-02 | 42.81 | 5.47 | 36.68 | 14.35 | .00380 | 5.636E-05 | 5.657E-05 | 1.666E-03 |
| 1.58 | 2.36 | 7.399E-01 | 9.520E-02 | 42.39 | 5.45 | 36.93 | 14.32 | .00382 | 5.674E-05 | 5.695E-05 | 1.659E-03 |
| 1.56 | 2.41 | 7.326E-01 | 9.499E-02 | 41.98 | 5.44 | 37.17 | 14.29 | .00383 | 5.709E-05 | 5.730E-05 | 1.652E-03 |
| 1.54 | 2.45 | 7.254E-01 | 9.476E-02 | 41.56 | 5.43 | 37.41 | 14.25 | .00385 | 5.741E-05 | 5.762E-05 | 1.644E-03 |
| 1.53 | 2.49 | 7.181E-01 | 9.451E-02 | 41.14 | 5.42 | 37.65 | 14.22 | .00387 | 5.769E-05 | 5.790E-05 | 1.635E-03 |
| 1.51 | 2.53 | 7.107E-01 | 9.424E-02 | 40.72 | 5.40 | 37.89 | 14.17 | .00389 | 5.794E-05 | 5.816E-05 | 1.626E-03 |
| 1.49 | 2.58 | 7.034E-01 | 9.395E-02 | 40.30 | 5.38 | 38.13 | 14.13 | .00392 | 5.816E-05 | 5.838E-05 | 1.616E-03 |
| 1.48 | 2.63 | 6.961E-01 | 9.364E-02 | 39.88 | 5.37 | 38.37 | 14.08 | .00394 | 5.835E-05 | 5.856E-05 | 1.606E-03 |
| 1.46 | 2.68 | 6.887E-01 | 9.332E-02 | 39.46 | 5.35 | 38.60 | 14.04 | .00397 | 5.850E-05 | 5.872E-05 | 1.594E-03 |
| 1.45 | 2.73 | 6.813E-01 | 9.297E-02 | 39.04 | 5.33 | 38.84 | 13.98 | .00400 | 5.861E-05 | 5.883E-05 | 1.582E-03 |
| 1.43 | 2.78 | 6.739E-01 | 9.260E-02 | 38.61 | 5.31 | 39.07 | 13.93 | .00403 | 5.869E-05 | 5.891E-05 | 1.570E-03 |
| 1.42 | 2.84 | 6.665E-01 | 9.221E-02 | 38.19 | 5.28 | 39.30 | 13.87 | .00407 | 5.872E-05 | 5.895E-05 | 1.557E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.40 | 2.90 | 6.590E-01 | 9.180E-02 | 37.76 | 5.26 | 39.53 | 13.81 | .00410 | 5.872E-05 | 5.895E-05 | 1.543E-03 |
| 1.39 | 2.96 | 6.516E-01 | 9.137E-02 | 37.33 | 5.24 | 39.76 | 13.74 | .00414 | 5.868E-05 | 5.891E-05 | 1.529E-03 |
| 1.38 | 3.02 | 6.440E-01 | 9.092E-02 | 36.90 | 5.21 | 39.98 | 13.68 | .00418 | 5.860E-05 | 5.883E-05 | 1.514E-03 |
| 1.36 | 3.08 | 6.365E-01 | 9.045E-02 | 36.47 | 5.18 | 40.21 | 13.60 | .00423 | 5.848E-05 | 5.871E-05 | 1.498E-03 |
| 1.35 | 3.15 | 6.289E-01 | 8.996E-02 | [illegible] | 5.15 | 40.43 | 13.53 | .00427 | 5.832E-05 | 5.855E-05 | 1.482E-03 |
| 1.34 | 3.22 | 6.213E-01 | 8.944E-02 | 35.60 | 5.12 | 40.66 | 13.45 | .00432 | 5.811E-05 | 5.835E-05 | 1.465E-03 |
| 1.33 | 3.30 | 6.136E-01 | 8.891E-02 | 35.16 | 5.09 | 40.88 | 13.37 | .00437 | 5.786E-05 | 5.810E-05 | 1.447E-03 |
| 1.31 | 3.38 | 6.059E-01 | 8.835E-02 | 34.71 | 5.06 | 41.10 | 13.29 | .00443 | 5.756E-05 | 5.780E-05 | 1.429E-03 |
| 1.30 | 3.46 | 5.981E-01 | 8.777E-02 | 34.27 | 5.03 | 41.32 | 13.20 | .00449 | 5.722E-05 | 5.746E-05 | 1.410E-03 |
| 1.29 | 3.55 | 5.903E-01 | 8.716E-02 | 33.82 | 4.99 | 41.54 | 13.11 | .00455 | 5.683E-05 | 5.708E-05 | 1.391E-03 |
| 1.28 | 3.64 | 5.825E-01 | 8.653E-02 | 33.37 | 4.96 | 41.76 | 13.02 | .00462 | 5.640E-05 | 5.664E-05 | 1.371E-03 |
| 1.27 | 3.73 | 5.746E-01 | 8.588E-02 | 32.92 | 4.92 | 41.97 | 12.92 | .00469 | 5.592E-05 | 5.616E-05 | 1.350E-03 |
| 1.26 | 3.84 | 5.666E-01 | 8.520E-02 | 32.46 | 4.88 | 42.19 | 12.82 | .00476 | 5.538E-05 | 5.563E-05 | 1.329E-03 |
| 1.24 | 3.94 | 5.586E-01 | 8.450E-02 | 32.00 | 4.84 | 42.40 | 12.71 | .00484 | 5.480E-05 | 5.505E-05 | 1.307E-03 |
| 1.23 | 4.05 | 5.505E-01 | 8.377E-02 | 31.54 | 4.80 | 42.61 | 12.60 | .00492 | 5.417E-05 | 5.442E-05 | 1.285E-03 |
| 1.22 | 4.17 | 5.423E-01 | 8.302E-02 | 31.07 | 4.76 | 42.83 | 12.49 | .00501 | 5.348E-05 | 5.373E-05 | 1.262E-03 |
| 1.21 | 4.30 | 5.341E-01 | 8.224E-02 | 30.60 | 4.71 | 43.04 | 12.37 | .00511 | 5.274E-05 | 5.300E-05 | 1.238E-03 |
| 1.20 | 4.43 | 5.258E-01 | 8.143E-02 | 30.13 | 4.67 | 43.25 | 12.25 | .00521 | 5.195E-05 | 5.221E-05 | 1.214E-03 |
| 1.19 | 4.58 | 5.174E-01 | 8.059E-02 | 29.65 | 4.62 | 43.46 | 12.12 | .00532 | 5.110E-05 | 5.136E-05 | 1.189E-03 |
| 1.18 | 4.73 | 5.089E-01 | 7.973E-02 | 29.16 | 4.57 | 43.66 | 11.99 | .00543 | 5.020E-05 | 5.046E-05 | 1.164E-03 |
| 1.17 | 4.89 | 5.004E-01 | 7.883E-02 | 28.67 | 4.52 | 43.87 | 11.86 | .00556 | 4.924E-05 | 4.950E-05 | 1.138E-03 |
| 1.16 | 5.07 | 4.918E-01 | 7.791E-02 | 28.18 | 4.46 | 44.07 | 11.72 | .00569 | 4.823E-05 | 4.848E-05 | 1.111E-03 |
| 1.15 | 5.26 | 4.830E-01 | 7.695E-02 | 27.68 | 4.41 | 44.28 | 11.57 | .00583 | 4.715E-05 | 4.741E-05 | 1.084E-03 |
| 1.14 | 5.46 | 4.742E-01 | 7.596E-02 | 27.17 | 4.35 | 44.48 | 11.42 | .00598 | 4.601E-05 | 4.627E-05 | 1.056E-03 |
| 1.14 | 5.68 | 4.653E-01 | 7.494E-02 | 26.66 | 4.29 | 44.68 | 11.27 | .00615 | 4.482E-05 | 4.508E-05 | 1.028E-03 |
| 1.13 | 5.91 | 4.563E-01 | 7.388E-02 | 26.14 | 4.23 | 44.88 | 11.11 | .00632 | 4.356E-05 | 4.382E-05 | 9.994E-04 |
| 1.12 | 6.17 | 4.471E-01 | 7.279E-02 | 25.62 | 4.17 | 45.08 | 10.95 | .00651 | 4.223E-05 | 4.249E-05 | 9.781E-04 |
| 1.11 | 6.45 | 4.379E-01 | 7.166E-02 | 25.09 | 4.11 | 45.28 | 10.78 | .00672 | 4.084E-05 | 4.110E-05 | 9.463E-04 |
| 1.10 | 6.76 | 4.285E-01 | 7.050E-02 | 24.55 | 4.04 | 45.48 | 10.60 | .00694 | 3.939E-05 | 3.964E-05 | 9.180E-04 |
| 1.09 | 7.09 | 4.191E-01 | 6.930E-02 | 24.01 | 3.97 | 45.67 | 10.42 | .00718 | 3.786E-05 | 3.812E-05 | 8.793E-04 |
| 1.08 | 7.47 | 4.095E-01 | 6.806E-02 | 23.46 | 3.90 | 45.87 | 10.24 | .00744 | 3.627E-05 | 3.652E-05 | 8.481E-04 |
| 1.08 | 7.88 | 3.998E-01 | 6.679E-02 | 22.91 | 3.83 | 46.06 | 10.04 | .00773 | 3.460E-05 | 3.485E-05 | 8.166E-04 |
| 1.07 | 8.35 | 3.900E-01 | 6.547E-02 | 22.34 | 3.75 | 46.25 | 9.85 | .00804 | 3.286E-05 | 3.311E-05 | 7.840E-04 |
| 1.06 | 8.87 | 3.800E-01 | 6.412E-02 | 21.77 | 3.67 | 46.43 | 9.64 | .00838 | 3.105E-05 | 3.129E-05 | 7.520E-04 |
| 1.05 | 9.46 | 3.700E-01 | 6.274E-02 | 21.20 | 3.59 | 46.62 | 9.44 | .00875 | 2.915E-05 | 2.939E-05 | 7.206E-04 |
| 1.04 | 10.14 | 3.599E-01 | 6.132E-02 | 20.62 | 3.51 | 46.80 | 9.22 | .00915 | 2.717E-05 | 2.741E-05 | 6.884E-04 |
| 1.04 | 10.92 | 3.498E-01 | 5.987E-02 | 20.04 | 3.43 | 46.97 | 9.01 | .00960 | 2.512E-05 | 2.534E-05 | 6.563E-04 |
| 1.03 | 11.82 | 3.397E-01 | 5.841E-02 | 19.47 | 3.35 | 47.14 | 8.79 | .01008 | 2.297E-05 | 2.319E-05 | 6.246E-04 |
| 1.02 | 12.90 | 3.297E-01 | 5.694E-02 | 18.89 | 3.26 | 47.31 | 8.56 | .01060 | 2.074E-05 | 2.095E-05 | 5.936E-04 |
| 1.01 | 14.19 | 3.200E-01 | 5.549E-02 | 18.33 | 3.18 | 47.46 | 8.35 | .01116 | 1.842E-05 | 1.862E-05 | 5.637E-04 |
| 1.01 | 15.77 | 3.106E-01 | 5.408E-02 | 17.80 | 3.10 | 47.61 | 8.13 | .01174 | 1.602E-05 | 1.620E-05 | 5.355E-04 |
| 1.00 | 17.74 | 3.021E-01 | 5.278E-02 | 17.31 | 3.02 | 47.74 | 7.94 | .01232 | 1.355E-05 | 1.370E-05 | 5.100E-04 |
| .99 | 20.27 | 2.948E-01 | 5.167E-02 | 16.89 | 2.96 | 47.84 | 7.77 | .01285 | 1.102E-05 | 1.115E-05 | 4.888E-04 |
| .99 | 23.65 | 2.899E-01 | 5.093E-02 | 16.61 | 2.92 | 47.91 | 7.66 | .01322 | 8.471E-06 | 8.578E-06 | 4.749E-04 |
| .98 | 28.38 | 2.891E-01 | 5.086E-02 | 16.57 | 2.91 | 47.92 | 7.65 | .01325 | 5.983E-06 | 6.058E-06 | 4.736E-04 |

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PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO

CINNABAR

PHASE MATCHING FOR POSITIVE BIREFRINGENT CRYSTAL

PUMP WAVELENGTH(MICRONS)=        1.060

NONLINEAR COEFFICIENTS(X10 E12 M/V)=        50.000        0.000        -0.000        -0.000        -0.000

CUTOFF WAVELENGTH=        30.000

RESULTS FOR TYPE I  (E + E = O) PHASE MATCHING ARE
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| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.12 | 2.12 | 4.995E-01 | 7.628E-02 | 28.62 | 4.37 | 38.53 | 10.80 | .00669 | 8.484E-05 | 8.538E-05 | 1.060E-03 |
| 2.09 | 2.15 | 4.995E-01 | 7.631E-02 | 28.62 | 4.37 | 38.53 | 10.80 | .00669 | 8.477E-05 | 8.530E-05 | 1.060E-03 |
| 2.06 | 2.18 | 4.993E-01 | 7.632E-02 | 28.61 | 4.37 | 38.54 | 10.80 | .00669 | 8.467E-05 | 8.520E-05 | 1.061E-03 |
| 2.04 | 2.21 | 4.991E-01 | 7.633E-02 | 28.60 | 4.37 | 38.55 | 10.80 | .00669 | 8.455E-05 | 8.509E-05 | 1.061E-03 |
| 2.01 | 2.24 | 4.988E-01 | 7.632E-02 | 28.58 | 4.37 | 38.56 | 10.80 | .00669 | 8.441E-05 | 8.494E-05 | 1.061E-03 |
| 1.99 | 2.27 | 4.984E-01 | 7.631E-02 | 28.55 | 4.37 | 38.58 | 10.80 | .00669 | 8.424E-05 | 8.477E-05 | 1.060E-03 |
| 1.96 | 2.30 | 4.979E-01 | 7.628E-02 | 28.53 | 4.37 | 38.60 | 10.80 | .00669 | 8.406E-05 | 8.459E-05 | 1.060E-03 |
| 1.94 | 2.34 | 4.973E-01 | 7.625E-02 | 28.49 | 4.37 | 38.62 | 10.79 | .00670 | 8.385E-05 | 8.438E-05 | 1.059E-03 |
| 1.92 | 2.37 | 4.966E-01 | 7.621E-02 | 28.45 | 4.37 | 38.65 | 10.79 | .00671 | 8.361E-05 | 8.414E-05 | 1.057E-03 |
| 1.89 | 2.41 | 4.958E-01 | 7.615E-02 | 28.41 | 4.36 | 38.68 | 10.78 | .00672 | 8.336E-05 | 8.388E-05 | 1.056E-03 |
| 1.87 | 2.45 | 4.950E-01 | 7.609E-02 | 28.36 | 4.36 | 38.72 | 10.77 | .00673 | 8.308E-05 | 8.360E-05 | 1.054E-03 |
| 1.85 | 2.48 | 4.940E-01 | 7.602E-02 | 28.31 | 4.36 | 38.76 | 10.76 | .00674 | 8.278E-05 | 8.330E-05 | 1.052E-03 |
| 1.83 | 2.52 | 4.930E-01 | 7.593E-02 | 28.25 | 4.35 | 38.80 | 10.75 | .00676 | 8.245E-05 | 8.298E-05 | 1.050E-03 |
| 1.81 | 2.56 | 4.918E-01 | 7.584E-02 | 28.18 | 4.35 | 38.85 | 10.73 | .00677 | 8.210E-05 | 8.263E-05 | 1.047E-03 |
| 1.79 | 2.61 | 4.906E-01 | 7.573E-02 | 28.11 | 4.34 | 38.90 | 10.72 | .00679 | 8.173E-05 | 8.225E-05 | 1.044E-03 |
| 1.77 | 2.65 | 4.893E-01 | 7.562E-02 | 28.03 | 4.33 | 38.95 | 10.70 | .00681 | 8.133E-05 | 8.186E-05 | 1.041E-03 |
| 1.75 | 2.69 | 4.879E-01 | 7.549E-02 | 27.95 | 4.33 | 39.01 | 10.69 | .00683 | 8.091E-05 | 8.143E-05 | 1.038E-03 |
| 1.73 | 2.74 | 4.864E-01 | 7.535E-02 | 27.87 | 4.32 | 39.08 | 10.67 | .00686 | 8.047E-05 | 8.099E-05 | 1.034E-03 |
| 1.71 | 2.79 | 4.848E-01 | 7.521E-02 | 27.78 | 4.31 | 39.14 | 10.65 | .00689 | 8.000E-05 | 8.052E-05 | 1.030E-03 |
| 1.69 | 2.84 | 4.831E-01 | 7.505E-02 | 27.68 | 4.30 | 39.21 | 10.62 | .00692 | 7.950E-05 | 8.002E-05 | 1.025E-03 |
| 1.67 | 2.89 | 4.813E-01 | 7.487E-02 | 27.58 | 4.29 | 39.29 | 10.60 | .00695 | 7.898E-05 | 7.950E-05 | 1.021E-03 |
| 1.66 | 2.94 | 4.794E-01 | 7.469E-02 | 27.47 | 4.28 | 39.36 | 10.57 | .00698 | 7.843E-05 | 7.895E-05 | 1.016E-03 |
| 1.64 | 3.00 | 4.774E-01 | 7.450E-02 | 27.35 | 4.27 | 39.44 | 10.55 | .00702 | 7.786E-05 | 7.837E-05 | 1.010E-03 |
| 1.62 | 3.06 | 4.753E-01 | 7.429E-02 | 27.23 | 4.26 | 39.53 | 10.52 | .00706 | 7.726E-05 | 7.777E-05 | 1.005E-03 |
| 1.61 | 3.12 | 4.731E-01 | 7.407E-02 | 27.11 | 4.24 | 39.62 | 10.48 | .00710 | 7.663E-05 | 7.714E-05 | 9.989E-04 |
| 1.59 | 3.18 | 4.709E-01 | 7.384E-02 | 26.98 | 4.23 | 39.71 | 10.45 | .00714 | 7.598E-05 | 7.649E-05 | 9.927E-04 |
| 1.57 | 3.24 | 4.685E-01 | 7.359E-02 | 26.84 | 4.22 | 39.81 | 10.42 | .00719 | 7.529E-05 | 7.580E-05 | 9.861E-04 |
| 1.56 | 3.31 | 4.660E-01 | 7.333E-02 | 26.70 | 4.20 | 39.91 | 10.38 | .00724 | 7.458E-05 | 7.509E-05 | 9.791E-04 |
| 1.54 | 3.39 | 4.634E-01 | 7.306E-02 | 26.55 | 4.19 | 40.01 | 10.34 | .00729 | 7.384E-05 | 7.434E-05 | 9.719E-04 |
| 1.53 | 3.46 | 4.607E-01 | 7.277E-02 | 26.40 | 4.17 | 40.12 | 10.30 | .00735 | 7.306E-05 | 7.357E-05 | 9.643E-04 |
| 1.51 | 3.53 | 4.579E-01 | 7.247E-02 | 26.24 | 4.15 | 40.23 | 10.26 | .00741 | 7.226E-05 | 7.277E-05 | 9.563E-04 |
| 1.50 | 3.61 | 4.550E-01 | 7.216E-02 | 26.07 | 4.13 | 40.34 | 10.21 | .00748 | 7.143E-05 | 7.193E-05 | 9.480E-04 |
| 1.49 | 3.70 | 4.520E-01 | 7.182E-02 | 25.90 | 4.12 | 40.46 | 10.17 | .00754 | 7.056E-05 | 7.106E-05 | 9.393E-04 |
| 1.47 | 3.79 | 4.489E-01 | 7.148E-02 | 25.72 | 4.10 | 40.58 | 10.12 | .00762 | 6.966E-05 | 7.016E-05 | 9.303E-04 |
| 1.46 | 3.88 | 4.457E-01 | 7.112E-02 | 25.54 | 4.07 | 40.71 | 10.07 | .00769 | 6.873E-05 | 6.923E-05 | 9.208E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.45 | 3.97 | 4.423E-01 | 7.074E-02 | 25.34 | 4.05 | 40.84 | 10.01 | .00778 | 6.776E-05 | 6.826E-05 | 9.111E-04 |
| 1.43 | 4.08 | 4.389E-01 | 7.034E-02 | 25.15 | 4.03 | 40.97 | 9.96 | .00786 | 6.676E-05 | 6.725E-05 | 9.009E-04 |
| 1.42 | 4.18 | 4.353E-01 | 6.993E-02 | 24.94 | 4.01 | 41.11 | 9.90 | .00796 | 6.572E-05 | 6.621E-05 | 8.904E-04 |
| 1.41 | 4.30 | 4.317E-01 | 6.950E-02 | 24.73 | 3.98 | 41.25 | 9.84 | .00805 | 6.464E-05 | 6.513E-05 | 8.794E-04 |
| 1.39 | 4.42 | 4.279E-01 | 6.905E-02 | 24.52 | 3.96 | 41.39 | 9.77 | .00816 | 6.353E-05 | 6.402E-05 | 8.681E-04 |
| 1.38 | 4.54 | 4.240E-01 | 6.858E-02 | 24.29 | 3.93 | 41.54 | 9.71 | .00827 | 6.238E-05 | 6.286E-05 | 8.564E-04 |
| 1.37 | 4.68 | 4.199E-01 | 6.809E-02 | 24.06 | 3.90 | 41.69 | 9.64 | .00839 | 6.119E-05 | 6.167E-05 | 8.443E-04 |
| 1.36 | 4.82 | 4.158E-01 | 6.759E-02 | 23.82 | 3.87 | 41.84 | 9.57 | .00851 | 5.995E-05 | 6.043E-05 | 8.318E-04 |
| 1.35 | 4.97 | 4.115E-01 | 6.706E-02 | 23.58 | 3.84 | 42.00 | 9.49 | .00865 | 5.868E-05 | 5.916E-05 | 8.188E-04 |
| 1.34 | 5.13 | 4.071E-01 | 6.651E-02 | 23.33 | 3.81 | 42.16 | 9.41 | .00879 | 5.736E-05 | 5.784E-05 | 8.055E-04 |
| 1.33 | 5.30 | 4.026E-01 | 6.594E-02 | 23.07 | 3.78 | 42.32 | 9.33 | .00894 | 5.600E-05 | 5.647E-05 | 7.918E-04 |
| 1.31 | 5.48 | 3.980E-01 | 6.535E-02 | 22.80 | 3.74 | 42.49 | 9.25 | .00910 | 5.459E-05 | 5.506E-05 | 7.776E-04 |
| 1.30 | 5.68 | 3.932E-01 | 6.474E-02 | 22.53 | 3.71 | 42.66 | 9.16 | .00927 | 5.313E-05 | 5.360E-05 | 7.631E-04 |
| 1.29 | 5.89 | 3.883E-01 | 6.410E-02 | 22.25 | 3.67 | 42.83 | 9.07 | .00946 | 5.163E-05 | 5.209E-05 | 7.481E-04 |
| 1.28 | 6.12 | 3.833E-01 | 6.344E-02 | 21.96 | 3.63 | 43.01 | 8.98 | .00965 | 5.008E-05 | 5.053E-05 | 7.328E-04 |
| 1.27 | 6.36 | 3.781E-01 | 6.275E-02 | 21.66 | 3.60 | 43.19 | 8.88 | .00986 | 4.847E-05 | 4.892E-05 | 7.170E-04 |
| 1.26 | 6.62 | 3.728E-01 | 6.204E-02 | 21.36 | 3.55 | 43.37 | 8.78 | .01009 | 4.681E-05 | 4.726E-05 | 7.009E-04 |
| 1.25 | 6.91 | 3.674E-01 | 6.131E-02 | 21.05 | 3.51 | 43.55 | 8.68 | .01033 | 4.510E-05 | 4.554E-05 | 6.844E-04 |
| 1.24 | 7.23 | 3.618E-01 | 6.055E-02 | 20.73 | 3.47 | 43.74 | 8.57 | .01058 | 4.333E-05 | 4.376E-05 | 6.676E-04 |
| 1.23 | 7.57 | 3.561E-01 | 5.977E-02 | 20.40 | 3.42 | 43.92 | 8.46 | .01086 | 4.150E-05 | 4.192E-05 | 6.504E-04 |
| 1.22 | 7.95 | 3.503E-01 | 5.896E-02 | 20.07 | 3.38 | 44.11 | 8.35 | .01116 | 3.960E-05 | 4.002E-05 | 6.330E-04 |
| 1.21 | 8.37 | 3.444E-01 | 5.813E-02 | 19.73 | 3.33 | 44.30 | 8.23 | .01148 | 3.765E-05 | 3.806E-05 | 6.152E-04 |
| 1.20 | 8.83 | 3.384E-01 | 5.728E-02 | 19.39 | 3.28 | 44.49 | 8.11 | .01182 | 3.563E-05 | 3.603E-05 | 5.973E-04 |
| 1.20 | 9.35 | 3.323E-01 | 5.643E-02 | 19.04 | 3.23 | 44.68 | 7.98 | .01218 | 3.354E-05 | 3.393E-05 | 5.792E-04 |
| 1.19 | 9.94 | 3.262E-01 | 5.551E-02 | 18.69 | 3.18 | 44.87 | 7.86 | .01257 | 3.139E-05 | 3.176E-05 | 5.611E-04 |
| 1.18 | 10.60 | 3.200E-01 | 5.461E-02 | 18.33 | 3.13 | 45.05 | 7.73 | .01298 | 2.916E-05 | 2.952E-05 | 5.430E-04 |
| 1.17 | 11.36 | 3.138E-01 | 5.370E-02 | 17.98 | 3.08 | 45.24 | 7.60 | .01342 | 2.686E-05 | 2.721E-05 | 5.251E-04 |
| 1.16 | 12.23 | 3.077E-01 | 5.280E-02 | 17.63 | 3.03 | 45.41 | 7.47 | .01388 | 2.450E-05 | 2.482E-05 | 5.076E-04 |
| 1.15 | 13.25 | 3.018E-01 | 5.192E-02 | 17.29 | 2.97 | 45.58 | 7.35 | .01435 | 2.206E-05 | 2.236E-05 | 4.908E-04 |
| 1.14 | 14.45 | 2.962E-01 | 5.108E-02 | 16.97 | 2.93 | 45.74 | 7.23 | .01482 | 1.955E-05 | 1.983E-05 | 4.751E-04 |
| 1.14 | 15.90 | 2.911E-01 | 5.031E-02 | 16.68 | 2.88 | 45.89 | 7.12 | .01526 | 1.700E-05 | 1.724E-05 | 4.609E-04 |
| 1.13 | 17.67 | 2.868E-01 | 4.967E-02 | 16.43 | 2.85 | 46.00 | 7.03 | .01566 | 1.440E-05 | 1.461E-05 | 4.491E-04 |
| 1.12 | 19.87 | 2.838E-01 | 4.922E-02 | 16.26 | 2.82 | 46.08 | 6.97 | .01594 | 1.179E-05 | 1.197E-05 | 4.411E-04 |
| 1.11 | 22.71 | 2.828E-01 | 4.909E-02 | 16.20 | 2.81 | 46.11 | 6.95 | .01602 | 9.208E-06 | 9.349E-06 | 4.389E-04 |
| 1.10 | 26.50 | 2.851E-01 | 4.951E-02 | 16.34 | 2.84 | 46.04 | 7.01 | .01576 | 6.738E-06 | 6.830E-06 | 4.462E-04 |

RESULTS FOR TYPE II (O + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | Q | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.12 | 2.12 | 7.306E-01 | 9.376E-02 | 41.86 | 5.37 | 37.24 | 13.27 | .00444 | 5.257E-05 | 5.279E-05 | 1.601E-03 |
| 2.09 | 2.15 | 7.365E-01 | 9.394E-02 | 42.20 | 5.38 | 37.04 | 13.30 | .00442 | 5.180E-05 | 5.202E-05 | 1.607E-03 |
| 2.06 | 2.18 | 7.424E-01 | 9.411E-02 | 42.53 | 5.39 | 36.84 | 13.32 | .00441 | 5.102E-05 | 5.123E-05 | 1.613E-03 |
| 2.04 | 2.21 | 7.482E-01 | 9.426E-02 | 42.87 | 5.40 | 36.64 | 13.34 | .00439 | 5.021E-05 | 5.042E-05 | 1.618E-03 |
| 2.01 | 2.24 | 7.541E-01 | 9.441E-02 | 43.21 | 5.41 | 36.44 | 13.36 | .00438 | 4.939E-05 | 4.959E-05 | 1.623E-03 |
| 1.99 | 2.27 | 7.600E-01 | 9.454E-02 | 43.54 | 5.42 | 36.24 | 13.38 | .00437 | 4.855E-05 | 4.875E-05 | 1.627E-03 |
| 1.96 | 2.30 | 7.659E-01 | 9.466E-02 | 43.88 | 5.42 | 36.04 | 13.40 | .00436 | 4.770E-05 | 4.789E-05 | 1.631E-03 |
| 1.94 | 2.34 | 7.718E-01 | 9.477E-02 | 44.22 | 5.43 | 35.83 | 13.41 | .00435 | 4.683E-05 | 4.702E-05 | 1.635E-03 |
| 1.92 | 2.37 | 7.777E-01 | 9.486E-02 | 44.56 | 5.44 | 35.63 | 13.43 | .00434 | 4.595E-05 | 4.614E-05 | 1.638E-03 |
| 1.89 | 2.41 | 7.836E-01 | 9.494E-02 | 44.90 | 5.44 | 35.42 | 13.44 | .00433 | 4.506E-05 | 4.524E-05 | 1.641E-03 |
| 1.87 | 2.45 | 7.896E-01 | 9.501E-02 | 45.24 | 5.44 | 35.21 | 13.45 | .00432 | 4.416E-05 | 4.434E-05 | 1.644E-03 |
| 1.85 | 2.48 | 7.956E-01 | 9.507E-02 | 45.58 | 5.45 | 34.99 | 13.46 | .00432 | 4.324E-05 | 4.342E-05 | 1.646E-03 |
| 1.83 | 2.52 | 8.015E-01 | 9.511E-02 | 45.92 | 5.45 | 34.78 | 13.46 | .00432 | 4.232E-05 | 4.249E-05 | 1.647E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.81 | 2.56 | 8.075E-01 | 9.514E-02 | 46.27 | 5.45 | 34.56 | 13.47 | .00431 | 4.139E-05 | 4.155E-05 | 1.648E-03 |
| 1.79 | 2.61 | 8.136E-01 | 9.516E-02 | 46.61 | 5.45 | 34.35 | 13.47 | .00431 | 4.045E-05 | 4.061E-05 | 1.649E-03 |
| 1.77 | 2.65 | 8.196E-01 | 9.517E-02 | 46.96 | 5.45 | 34.12 | 13.47 | .00431 | 3.950E-05 | 3.966E-05 | 1.649E-03 |
| 1.75 | 2.69 | 8.257E-01 | 9.516E-02 | 47.31 | 5.45 | 33.90 | 13.47 | .00431 | 3.855E-05 | 3.870E-05 | 1.649E-03 |
| 1.73 | 2.74 | 8.318E-01 | 9.513E-02 | 47.66 | 5.45 | 33.68 | 13.47 | .00431 | 3.759E-05 | 3.774E-05 | 1.648E-03 |
| 1.71 | 2.79 | 8.380E-01 | 9.509E-02 | 48.01 | 5.45 | 33.45 | 13.46 | .00432 | 3.663E-05 | 3.678E-05 | 1.647E-03 |
| 1.69 | 2.84 | 8.441E-01 | 9.50[illegible]E-02 | 48.37 | 5.45 | 33.22 | 13.45 | .00432 | 3.566E-05 | 3.581E-05 | 1.645E-03 |
| 1.67 | 2.89 | 8.504E-01 | 9.498E-02 | 48.72 | 5.44 | 32.99 | 13.44 | .00433 | 3.469E-05 | 3.483E-05 | 1.642E-03 |
| 1.66 | 2.94 | 8.566E-01 | 9.489E-02 | 49.08 | 5.44 | 32.75 | 13.43 | .00434 | 3.372E-05 | 3.386E-05 | 1.640E-03 |
| 1.64 | 3.00 | 8.629E-01 | 9.480E-02 | 49.44 | 5.43 | 32.51 | 13.42 | .00434 | 3.275E-05 | 3.288E-05 | 1.636E-03 |
| 1.62 | 3.06 | 8.693E-01 | 9.468E-02 | 49.81 | 5.42 | 32.27 | 13.40 | .00435 | 3.178E-05 | 3.191E-05 | 1.632E-03 |
| 1.61 | 3.12 | 8.757E-01 | 9.455E-02 | 50.17 | 5.42 | 32.02 | 13.38 | .00437 | 3.081E-05 | 3.093E-05 | 1.628E-03 |
| 1.59 | 3.18 | 8.821E-01 | 9.440E-02 | 50.54 | 5.41 | 31.78 | 13.36 | .00438 | 2.984E-05 | 2.996E-05 | 1.623E-03 |
| 1.57 | 3.24 | 8.887E-01 | 9.424E-02 | 50.92 | 5.40 | 31.52 | 13.34 | .00440 | 2.887E-05 | 2.899E-05 | 1.617E-03 |
| 1.56 | 3.31 | 8.952E-01 | 9.405E-02 | 51.29 | 5.39 | 31.27 | 13.31 | .00441 | 2.790E-05 | 2.802E-05 | 1.611E-03 |
| 1.54 | 3.38 | 9.019E-01 | 9.385E-02 | 51.68 | 5.38 | 31.01 | 13.28 | .00443 | 2.694E-05 | 2.706E-05 | 1.604E-03 |
| 1.53 | 3.46 | 9.086E-01 | 9.363E-02 | 52.06 | 5.36 | 30.74 | 13.25 | .00445 | 2.599E-05 | 2.610E-05 | 1.596E-03 |
| 1.51 | 3.53 | 9.155E-01 | 9.338E-02 | 52.45 | 5.35 | 30.47 | 13.22 | .00448 | 2.504E-05 | 2.514E-05 | 1.588E-03 |
| 1.50 | 3.61 | 9.224E-01 | 9.312E-02 | 52.85 | 5.34 | 30.20 | 13.18 | .00450 | 2.409E-05 | 2.420E-05 | 1.579E-03 |
| 1.49 | 3.70 | 9.294E-01 | 9.283E-02 | 53.25 | 5.32 | 29.92 | 13.14 | .00453 | 2.316E-05 | 2.325E-05 | 1.569E-03 |
| 1.47 | 3.79 | 9.365E-01 | 9.252E-02 | 53.66 | 5.30 | 29.63 | 13.10 | .00456 | 2.223E-05 | 2.232E-05 | 1.559E-03 |
| 1.46 | 3.88 | 9.438E-01 | 9.218E-02 | 54.07 | 5.28 | 29.34 | 13.05 | .00459 | 2.131E-05 | 2.140E-05 | 1.547E-03 |
| 1.45 | 3.97 | 9.511E-01 | 9.181E-02 | 54.50 | 5.26 | 29.04 | 13.00 | .00463 | 2.039E-05 | 2.048E-05 | 1.535E-03 |
| 1.43 | 4.08 | 9.587E-01 | 9.142E-02 | 54.93 | 5.24 | 28.73 | 12.94 | .00467 | 1.949E-05 | 1.958E-05 | 1.522E-03 |
| 1.42 | 4.18 | 9.663E-01 | 9.099E-02 | 55.37 | 5.21 | 28.42 | 12.88 | .00471 | 1.860E-05 | 1.869E-05 | 1.508E-03 |
| 1.41 | 4.30 | 9.742E-01 | 9.053E-02 | 55.82 | 5.19 | 28.09 | 12.81 | .00476 | 1.772E-05 | 1.780E-05 | 1.492E-03 |
| 1.39 | 4.42 | 9.822E-01 | 9.004E-02 | 56.29 | 5.16 | 27.76 | 12.74 | .00481 | 1.686E-05 | 1.693E-05 | 1.476E-03 |
| 1.38 | 4.54 | 9.905E-01 | 8.950E-02 | 56.75 | 5.13 | 27.41 | 12.67 | .00487 | 1.600E-05 | 1.608E-05 | 1.458E-03 |
| 1.37 | 4.68 | 9.990E-01 | 8.892E-02 | 57.24 | 5.09 | 27.06 | 12.59 | .00494 | 1.516E-05 | 1.523E-05 | 1.440E-03 |
| 1.36 | 4.82 | 1.008E+00 | 8.828E-02 | 57.74 | 5.06 | 26.64 | 12.50 | .00501 | 1.434E-05 | 1.441E-05 | 1.419E-03 |
| 1.35 | 4.97 | 1.017E+00 | 8.760E-02 | 58.27 | 5.02 | 26.30 | 12.40 | .00508 | 1.353E-05 | 1.359E-05 | 1.397E-03 |
| 1.34 | 5.13 | 1.026E+00 | 8.685E-02 | 58.81 | 4.98 | 25.90 | 12.29 | .00517 | 1.274E-05 | 1.280E-05 | 1.373E-03 |
| [illegible] | 5.30 | 1.036E+00 | 8.604E-02 | 59.37 | 4.93 | 25.47 | 12.18 | .00527 | 1.196E-05 | 1.202E-05 | 1.348E-03 |
| 1.31 | 5.48 | 1.047E+00 | 8.514E-02 | 59.96 | 4.88 | 25.03 | 12.05 | .00538 | 1.120E-05 | 1.125E-05 | 1.320E-03 |
| 1.30 | 5.68 | 1.057E+00 | 8.415E-02 | 60.58 | 4.82 | 24.56 | 11.91 | .00551 | 1.046E-05 | 1.051E-05 | 1.289E-03 |
| 1.29 | 5.89 | 1.069E+00 | 8.306E-02 | 61.24 | 4.76 | 24.06 | 11.76 | .00565 | 9.733E-06 | 9.795E-06 | 1.256E-03 |
| 1.28 | 6.12 | 1.081E+00 | 8.185E-02 | 61.94 | 4.69 | 23.52 | 11.59 | .00582 | 9.029E-06 | 9.079E-06 | 1.220E-03 |
| 1.27 | 6.36 | 1.094E+00 | 8.048E-02 | 62.69 | 4.61 | 22.94 | 11.39 | .00602 | 8.346E-06 | 8.393E-06 | 1.179E-03 |
| 1.26 | 6.62 | 1.108E+00 | 7.893E-02 | 63.50 | 4.52 | 22.31 | 11.17 | .00625 | 7.682E-06 | 7.720E-06 | 1.134E-03 |
| 1.25 | 6.91 | 1.124E+00 | 7.716E-02 | 64.38 | 4.42 | 21.62 | 10.92 | .00654 | 7.041E-06 | 7.094E-06 | 1.084E-03 |
| 1.24 | 7.23 | 1.141E+00 | 7.512E-02 | 65.35 | 4.30 | 20.85 | 10.63 | .00690 | 6.421E-06 | 6.463E-06 | 1.027E-03 |
| 1.23 | 7.57 | 1.160E+00 | 7.272E-02 | 66.44 | 4.17 | 19.99 | 10.29 | .00736 | 5.824E-06 | 5.865E-06 | 9.629E-04 |
| 1.22 | 7.95 | 1.181E+00 | 6.986E-02 | 67.67 | 4.00 | 19.00 | 9.89 | .00797 | 5.250E-06 | 5.290E-06 | 8.885E-04 |
| 1.21 | 8.37 | 1.206E+00 | 6.637E-02 | 69.09 | 3.80 | 17.85 | 9.39 | .00883 | 4.700E-06 | 4.739E-06 | 8.020E-04 |
| 1.20 | 8.83 | 1.235E+00 | 6.200E-02 | 70.77 | 3.55 | 16.47 | 8.78 | .01010 | 4.174E-06 | 4.214E-06 | 6.999E-04 |
| 1.20 | 9.35 | 1.271E+00 | 5.632E-02 | 72.83 | 3.23 | 14.76 | 7.97 | .01222 | 3.672E-06 | 3.715E-06 | 5.775E-04 |
| 1.19 | 9.94 | 1.318E+00 | 4.849E-02 | 75.50 | 2.78 | 12.52 | 6.86 | .01642 | 3.192E-06 | 3.242E-06 | 4.281E-04 |
| 1.18 | 10.60 | 1.385E+00 | 3.645E-02 | 79.33 | 2.09 | 9.25 | 5.16 | .02871 | 2.721E-06 | 2.796E-06 | 2.419E-04 |
| 1.17 | 11.36 | 1.547E+00 | 4.853E-03 | 89.61 | .29 | 1.21 | .69 | .65059 | 9.300E-07 | 2.379E-06 | 1.817E-05 |

PHASE MATCHING CUTS OFF AT SIGNAL= 1.161 AND IDLER= 12.231

PHASE MATCHING CUTS OFF AT SIGNAL= 1.152 AND IDLER= 13.258

PHASE MATCHING CUTS OFF AT SIGNAL= 1.144 AND IDLER= 14.455

PHASE MATCHING CUTS OFF AT SIGNAL= 1.136 AND IDLER= 15.900

PHASE MATCHING CUTS OFF AT SIGNAL= 1.128 AND IDLER= 17.667

PHASE MATCHING CUTS OFF AT SIGNAL= 1.120 AND IDLER= 19.875

PHASE MATCHING CUTS OFF AT SIGNAL= 1.112 AND IDLER= 22.714

PHASE MATCHING CUTS OFF AT SIGNAL= 1.104 AND IDLER= 26.500

RESULTS FOR TYPE II (E + O = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | R | H(R) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.12 | 2.12 | 7.306E-01 | 9.376E-02 | 41.86 | 5.37 | 37.24 | 13.27 | .00444 | 5.257E-05 | 5.279E-05 | 1.601E-03 |
| 2.09 | 2.15 | 7.248E-01 | 9.357E-02 | 41.53 | 5.36 | 37.43 | 13.24 | .00446 | 5.332E-05 | 5.355E-05 | 1.594E-03 |
| 2.06 | 2.18 | 7.189E-01 | 9.336E-02 | 41.19 | 5.35 | 37.63 | 13.22 | .00448 | 5.405E-05 | 5.428E-05 | 1.587E-03 |
| 2.04 | 2.21 | 7.131E-01 | 9.315E-02 | 40.85 | 5.34 | 37.82 | 13.19 | .00450 | 5.476E-05 | 5.499E-05 | 1.580E-03 |
| 2.01 | 2.24 | 7.072E-01 | 9.292E-02 | 40.52 | 5.32 | 38.01 | 13.15 | .00452 | 5.545E-05 | 5.568E-05 | 1.572E-03 |
| 1.99 | 2.27 | 7.013E-01 | 9.268E-02 | 40.18 | 5.31 | 38.20 | 13.12 | .00454 | 5.611E-05 | 5.635E-05 | 1.564E-03 |
| 1.96 | 2.30 | 6.955E-01 | 9.243E-02 | 39.85 | 5.30 | 38.39 | 13.08 | .00457 | 5.675E-05 | 5.699E-05 | 1.556E-03 |
| 1.94 | 2.34 | 6.896E-01 | 9.217E-02 | 39.51 | 5.28 | 38.58 | 13.05 | .00459 | 5.737E-05 | 5.761E-05 | 1.547E-03 |
| 1.92 | 2.37 | 6.837E-01 | 9.189E-02 | 39.17 | 5.26 | 38.76 | 13.01 | .00462 | 5.795E-05 | 5.821E-05 | 1.537E-03 |
| 1.89 | 2.41 | 6.778E-01 | 9.160E-02 | 38.84 | 5.25 | 38.95 | 12.97 | .00465 | 5.852E-05 | 5.877E-05 | 1.528E-03 |
| 1.87 | 2.45 | 6.719E-01 | 9.130E-02 | 38.50 | 5.23 | 39.13 | 12.92 | .00468 | 5.905E-05 | 5.931E-05 | 1.518E-03 |
| 1.85 | 2.48 | 6.660E-01 | 9.099E-02 | 38.16 | 5.21 | 39.31 | 12.88 | .00471 | 5.956E-05 | 5.982E-05 | 1.507E-03 |
| 1.83 | 2.52 | 6.601E-01 | 9.067E-02 | 37.82 | 5.19 | 39.50 | 12.83 | .00475 | 6.004E-05 | 6.030E-05 | 1.497E-03 |
| 1.81 | 2.56 | 6.542E-01 | 9.033E-02 | 37.48 | 5.18 | 39.68 | 12.79 | .00478 | 6.048E-05 | 6.076E-05 | 1.486E-03 |
| 1.79 | 2.61 | 6.482E-01 | 8.998E-02 | 37.14 | 5.16 | 39.86 | 12.74 | .00482 | 6.090E-05 | 6.117E-05 | 1.474E-03 |
| 1.77 | 2.65 | 6.423E-01 | 8.962E-02 | 36.80 | 5.13 | 40.04 | 12.69 | .00486 | 6.128E-05 | 6.156E-05 | 1.462E-03 |
| 1.75 | 2.69 | 6.363E-01 | 8.924E-02 | 36.46 | 5.11 | 40.22 | 12.63 | .00490 | 6.163E-05 | 6.192E-05 | 1.450E-03 |
| 1.73 | 2.74 | 6.303E-01 | 8.886E-02 | 36.11 | 5.09 | 40.39 | 12.58 | .00494 | 6.195E-05 | 6.224E-05 | 1.438E-03 |
| 1.71 | 2.79 | 6.243E-01 | 8.846E-02 | 35.77 | 5.07 | 40.57 | 12.52 | .00499 | 6.223E-05 | 6.252E-05 | 1.425E-03 |
| 1.69 | 2.84 | 6.183E-01 | 8.804E-02 | 35.42 | 5.04 | 40.74 | 12.46 | .00503 | 6.248E-05 | 6.277E-05 | 1.411E-03 |
| 1.67 | 2.89 | 6.122E-01 | 8.762E-02 | 35.08 | 5.02 | 40.92 | 12.40 | .00508 | 6.269E-05 | 6.299E-05 | 1.398E-03 |
| 1.66 | 2.94 | 6.061E-01 | 8.718E-02 | 34.73 | 4.99 | 41.09 | 12.34 | .00513 | 6.286E-05 | 6.316E-05 | 1.384E-03 |
| 1.64 | 3.00 | 6.000E-01 | 8.672E-02 | 34.38 | 4.97 | 41.27 | 12.28 | .00519 | 6.299E-05 | 6.330E-05 | 1.369E-03 |
| 1.62 | 3.06 | 5.939E-01 | 8.626E-02 | 34.03 | 4.94 | 41.44 | 12.21 | .00524 | 6.308E-05 | 6.340E-05 | 1.355E-03 |
| 1.61 | 3.12 | 5.878E-01 | 8.578E-02 | 33.68 | 4.91 | 41.61 | 12.14 | .00530 | 6.314E-05 | 6.345E-05 | 1.340E-03 |
| 1.59 | 3.18 | 5.816E-01 | 8.528E-02 | 33.32 | 4.89 | 41.78 | 12.07 | .00536 | 6.315E-05 | 6.347E-05 | 1.324E-03 |
| 1.57 | 3.24 | 5.754E-01 | 8.477E-02 | 32.97 | 4.86 | 41.95 | 12.00 | .00543 | 6.312E-05 | 6.344E-05 | 1.309E-03 |
| 1.56 | 3.31 | 5.691E-01 | 8.425E-02 | 32.61 | 4.83 | 42.12 | 11.93 | .00549 | 6.304E-05 | 6.337E-05 | 1.292E-03 |
| 1.54 | 3.38 | 5.629E-01 | 8.371E-02 | 32.25 | 4.80 | 42.29 | 11.85 | .00556 | 6.292E-05 | 6.325E-05 | 1.276E-03 |
| 1.53 | 3.46 | 5.566E-01 | 8.316E-02 | 31.89 | 4.76 | 42.45 | 11.77 | .00564 | 6.276E-05 | 6.309E-05 | 1.259E-03 |
| 1.51 | 3.53 | 5.502E-01 | 8.259E-02 | 31.52 | 4.73 | 42.62 | 11.69 | .00572 | 6.255E-05 | 6.289E-05 | 1.242E-03 |
| 1.50 | 3.61 | 5.438E-01 | 8.201E-02 | 31.16 | 4.70 | 42.79 | 11.61 | .00580 | 6.229E-05 | 6.263E-05 | 1.225E-03 |
| 1.49 | 3.70 | 5.374E-01 | 8.141E-02 | 30.79 | 4.66 | 42.95 | 11.52 | .00588 | 6.199E-05 | 6.233E-05 | 1.207E-03 |
| 1.47 | 3.79 | 5.309E-01 | 8.079E-02 | 30.42 | 4.63 | 43.12 | 11.44 | .00597 | 6.163E-05 | 6.198E-05 | 1.189E-03 |
| 1.46 | 3.88 | 5.244E-01 | 8.016E-02 | 30.05 | 4.59 | 43.28 | 11.35 | .00607 | 6.123E-05 | 6.158E-05 | 1.170E-03 |
| 1.45 | 3.97 | 5.179E-01 | 7.952E-02 | 29.67 | 4.56 | 43.44 | 11.26 | .00616 | 6.077E-05 | 6.113E-05 | 1.151E-03 |
| 1.43 | 4.08 | 5.113E-01 | 7.885E-02 | 29.30 | 4.52 | 43.61 | 11.16 | .00627 | 6.027E-05 | 6.062E-05 | 1.132E-03 |
| 1.42 | 4.18 | 5.047E-01 | 7.817E-02 | 28.92 | 4.48 | 43.77 | 11.06 | .00638 | 5.971E-05 | 6.006E-05 | 1.113E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.41 | 4.30 | 4.990E-01 | 7.747E-02 | 29.53 | 4.44 | 43.93 | 10.97 | .00649 | 5.909E-05 | 5.945E-05 | 1.093E-03 |
| 1.39 | 4.42 | 4.912E-01 | 7.675E-02 | 28.15 | 4.40 | 44.09 | 10.86 | .00661 | 5.842E-05 | 5.878E-05 | 1.073E-03 |
| 1.38 | 4.54 | 4.844E-01 | 7.602E-02 | 27.76 | 4.36 | 44.25 | 10.76 | .00674 | 5.769E-05 | 5.806E-05 | 1.052E-03 |
| 1.37 | 4.68 | 4.776E-01 | 7.526E-02 | 27.36 | 4.31 | 44.41 | 10.65 | .00688 | 5.691E-05 | 5.728E-05 | 1.031E-03 |
| 1.36 | 4.82 | 4.707E-01 | 7.449E-02 | 26.97 | 4.27 | 44.56 | 10.54 | .00702 | 5.607E-05 | 5.644E-05 | 1.010E-03 |
| 1.35 | 4.97 | 4.637E-01 | 7.369E-02 | 26.57 | 4.22 | 44.72 | 10.43 | .00717 | 5.517E-05 | 5.554E-05 | 9.880E-04 |
| 1.34 | 5.13 | 4.567E-01 | 7.289E-02 | 26.17 | 4.18 | 44.88 | 10.32 | .00733 | 5.420E-05 | 5.458E-05 | 9.671E-04 |
| 1.33 | 5.30 | 4.496E-01 | 7.205E-02 | 25.76 | 4.13 | 45.03 | 10.20 | .00750 | 5.318E-05 | 5.355E-05 | 9.451E-04 |
| 1.31 | 5.48 | 4.425E-01 | 7.119E-02 | 25.35 | 4.08 | 45.19 | 10.08 | .00768 | 5.209E-05 | 5.247E-05 | 9.228E-04 |
| 1.30 | 5.68 | 4.352E-01 | 7.032E-02 | 24.94 | 4.03 | 45.34 | 9.95 | .00787 | 5.094E-05 | 5.132E-05 | 9.003E-04 |
| 1.29 | 5.89 | 4.280E-01 | 6.942E-02 | 24.52 | 3.98 | 45.49 | 9.83 | .00807 | 4.972E-05 | 5.010E-05 | 8.774E-04 |
| 1.28 | 6.12 | 4.206E-01 | 6.850E-02 | 24.10 | 3.92 | 45.64 | 9.70 | .00829 | 4.843E-05 | 4.881E-05 | 8.546E-04 |
| 1.27 | 6.36 | 4.132E-01 | 6.756E-02 | 23.67 | 3.87 | 45.79 | 9.56 | .00852 | 4.708E-05 | 4.746E-05 | 8.311E-04 |
| 1.26 | 6.62 | 4.057E-01 | 6.660E-02 | 23.24 | 3.82 | 45.94 | 9.43 | .00877 | 4.565E-05 | 4.603E-05 | 8.075E-04 |
| 1.25 | 6.91 | 3.981E-01 | 6.561E-02 | 22.81 | 3.76 | 46.09 | 9.29 | .00903 | 4.416E-05 | 4.453E-05 | 7.838E-04 |
| 1.24 | 7.23 | 3.905E-01 | 6.460E-02 | 22.37 | 3.70 | 46.24 | 9.14 | .00931 | 4.259E-05 | 4.296E-05 | 7.600E-04 |
| 1.23 | 7.57 | 3.828E-01 | 6.358E-02 | 21.93 | 3.64 | 46.38 | 9.00 | .00961 | 4.094E-05 | 4.131E-05 | 7.357E-04 |
| 1.22 | 7.95 | 3.751E-01 | 6.253E-02 | 21.49 | 3.58 | 46.52 | 8.85 | .00993 | 3.922E-05 | 3.959E-05 | 7.110E-04 |
| 1.21 | 8.37 | 3.673E-01 | 6.146E-02 | 21.04 | 3.52 | 46.67 | 8.70 | .01028 | 3.742E-05 | 3.778E-05 | 6.877E-04 |
| 1.20 | 8.83 | 3.595E-01 | 6.037E-02 | 20.60 | 3.46 | 46.80 | 8.55 | .01065 | 3.554E-05 | 3.590E-05 | 6.636E-04 |
| 1.20 | 9.35 | 3.516E-01 | 5.926E-02 | 20.15 | 3.40 | 46.94 | 8.39 | .01105 | 3.357E-05 | 3.392E-05 | 6.395E-04 |
| 1.19 | 9.94 | 3.438E-01 | 5.815E-02 | 19.70 | 3.33 | 47.07 | 8.23 | .01147 | 3.152E-05 | 3.187E-05 | 6.156E-04 |
| 1.18 | 10.60 | 3.360E-01 | 5.702E-02 | 19.25 | 3.27 | 47.20 | 8.07 | .01192 | 2.939E-05 | 2.972E-05 | 5.921E-04 |
| 1.17 | 11.36 | 3.282E-01 | 5.590E-02 | 18.81 | 3.20 | 47.33 | 7.91 | .01240 | 2.717E-05 | 2.749E-05 | 5.690E-04 |
| 1.16 | 12.23 | 3.207E-01 | 5.479E-02 | 18.37 | 3.14 | 47.45 | 7.76 | .01290 | 2.486E-05 | 2.517E-05 | 5.463E-04 |
| 1.15 | 13.25 | 3.133E-01 | 5.370E-02 | 17.95 | 3.08 | 47.57 | 7.60 | .01342 | 2.247E-05 | 2.276E-05 | 5.250E-04 |
| 1.14 | 14.45 | 3.063E-01 | 5.266E-02 | 17.55 | 3.02 | 47.67 | 7.45 | .01395 | 2.000E-05 | 2.027E-05 | 5.049E-04 |
| 1.14 | 15.90 | 2.999E-01 | 5.169E-02 | 17.18 | 2.96 | 47.77 | 7.32 | .01447 | 1.746E-05 | 1.770E-05 | 4.866E-04 |
| 1.13 | 17.67 | 2.944E-01 | 5.086E-02 | 16.87 | 2.91 | 47.85 | 7.20 | .01494 | 1.487E-05 | 1.508E-05 | 4.710E-04 |
| 1.12 | 19.87 | 2.901E-01 | 5.022E-02 | 16.62 | 2.88 | 47.91 | 7.11 | .01532 | 1.224E-05 | 1.242E-05 | 4.593E-04 |
| 1.11 | 22.71 | 2.879E-01 | 4.991E-02 | 16.50 | 2.86 | 47.94 | 7.07 | .01551 | 9.636E-06 | 9.778E-06 | 4.536E-04 |
| 1.10 | 26.50 | 2.831E-01 | 5.013E-02 | 16.56 | 2.87 | 47.93 | 7.10 | .01537 | 7.112E-06 | 7.216E-06 | 4.577E-04 |

PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO

CINNABAR

PHASE MATCHING FOR POSITIVE BIREFRINGENT CRYSTAL

PUMP WAVELENGTH(MICRONS)= 1.300

NONLINEAR COEFFICIENTS(X10 E12 M/V)= 50.000 0.000 -0.000 -0.000 -0.000

CUTOFF WAVELENGTH= 30.000

RESULTS FOR TYPE I (E + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.68 | 2.60 | 4.008E-01 | 6.400E-02 | 22.97 | 3.67 | 42.39 | 8.14 | .01172 | 9.929E-05 | 1.004E-04 | 7.410E-04 |
| 2.57 | 2.64 | 4.008E-01 | 6.401E-02 | 22.96 | 3.67 | 42.39 | 8.14 | .01171 | 9.922E-05 | 1.003E-04 | 7.413E-04 |
| 2.53 | 2.67 | 4.007E-01 | 6.402E-02 | 22.96 | 3.67 | 42.39 | 8.14 | .01171 | 9.912E-05 | 1.002E-04 | 7.414E-04 |
| 2.50 | 2.71 | 4.005E-01 | 6.401E-02 | 22.95 | 3.67 | 42.40 | 8.14 | .01171 | 9.898E-05 | 1.001E-04 | 7.413E-04 |
| 2.47 | 2.75 | 4.003E-01 | 6.400E-02 | 22.94 | 3.67 | 42.41 | 8.14 | .01172 | 9.881E-05 | 9.991E-05 | 7.410E-04 |
| 2.44 | 2.79 | 4.000E-01 | 6.399E-02 | 22.92 | 3.67 | 42.42 | 8.14 | .01172 | 9.861E-05 | 9.970E-05 | 7.405E-04 |
| 2.41 | 2.83 | 3.997E-01 | 6.395E-02 | 22.90 | 3.66 | 42.43 | 8.14 | .01173 | 9.837E-05 | 9.946E-05 | 7.398E-04 |
| 2.38 | 2.87 | 3.992E-01 | 6.391E-02 | 22.87 | 3.66 | 42.45 | 8.13 | .01175 | 9.810E-05 | 9.919E-05 | 7.389E-04 |
| 2.35 | 2.91 | 3.987E-01 | 6.387E-02 | 22.85 | 3.66 | 42.46 | 8.13 | .01177 | 9.779E-05 | 9.888E-05 | 7.378E-04 |
| 2.32 | 2.95 | 3.982E-01 | 6.381E-02 | 22.81 | 3.66 | 42.49 | 8.12 | .01179 | 9.746E-05 | 9.854E-05 | 7.366E-04 |
| 2.29 | 3.00 | 3.976E-01 | 6.375E-02 | 22.78 | 3.65 | 42.51 | 8.11 | .01181 | 9.709E-05 | 9.817E-05 | 7.351E-04 |
| 2.27 | 3.05 | 3.969E-01 | 6.367E-02 | 22.74 | 3.65 | 42.53 | 8.10 | .01184 | 9.668E-05 | 9.776E-05 | 7.334E-04 |
| 2.24 | 3.10 | 3.961E-01 | 6.359E-02 | 22.70 | 3.64 | 42.56 | 8.09 | .01187 | 9.624E-05 | 9.732E-05 | 7.315E-04 |
| 2.22 | 3.15 | 3.953E-01 | 6.350E-02 | 22.65 | 3.64 | 42.59 | 8.08 | .01190 | 9.577E-05 | 9.684E-05 | 7.294E-04 |
| 2.19 | 3.20 | 3.944E-01 | 6.340E-02 | 22.60 | 3.63 | 42.62 | 8.07 | .01194 | 9.526E-05 | 9.633E-05 | 7.271E-04 |
| 2.17 | 3.25 | 3.934E-01 | 6.329E-02 | 22.54 | 3.63 | 42.65 | 8.05 | .01198 | 9.471E-05 | 9.579E-05 | 7.246E-04 |
| 2.14 | 3.31 | 3.924E-01 | 6.317E-02 | 22.48 | 3.62 | 42.69 | 8.04 | .01202 | 9.413E-05 | 9.521E-05 | 7.219E-04 |
| 2.12 | 3.36 | 3.913E-01 | 6.305E-02 | 22.42 | 3.61 | 42.73 | 8.02 | .01207 | 9.352E-05 | 9.459E-05 | 7.190E-04 |
| 2.10 | 3.42 | 3.902E-01 | 6.291E-02 | 22.36 | 3.60 | 42.77 | 8.00 | .01212 | 9.287E-05 | 9.394E-05 | 7.159E-04 |
| 2.07 | 3.48 | 3.889E-01 | 6.276E-02 | 22.28 | 3.60 | 42.81 | 7.98 | .01218 | 9.219E-05 | 9.325E-05 | 7.126E-04 |
| 2.05 | 3.55 | 3.877E-01 | 6.261E-02 | 22.21 | 3.59 | 42.86 | 7.96 | .01224 | 9.147E-05 | 9.253E-05 | 7.091E-04 |
| 2.03 | 3.61 | 3.863E-01 | 6.244E-02 | 22.13 | 3.58 | 42.90 | 7.94 | .01230 | 9.071E-05 | 9.177E-05 | 7.053E-04 |
| 2.01 | 3.68 | 3.849E-01 | 6.227E-02 | 22.05 | 3.57 | 42.95 | 7.92 | .01237 | 8.991E-05 | 9.097E-05 | 7.014E-04 |
| 1.99 | 3.75 | 3.834E-01 | 6.208E-02 | 21.96 | 3.56 | 43.00 | 7.90 | .01244 | 8.908E-05 | 9.013E-05 | 6.972E-04 |
| 1.97 | 3.82 | 3.818E-01 | 6.189E-02 | 21.87 | 3.55 | 43.06 | 7.87 | .01252 | 8.821E-05 | 8.926E-05 | 6.929E-04 |
| 1.95 | 3.90 | 3.801E-01 | 6.169E-02 | 21.78 | 3.53 | 43.12 | 7.85 | .01260 | 8.730E-05 | 8.835E-05 | 6.883E-04 |
| 1.93 | 3.98 | 3.784E-01 | 6.147E-02 | 21.69 | 3.52 | 43.17 | 7.82 | .01269 | 8.636E-05 | 8.742E-05 | 6.835E-04 |
| 1.91 | 4.06 | 3.767E-01 | 6.125E-02 | 21.59 | 3.51 | 43.24 | 7.79 | .01279 | 8.537E-05 | 8.641E-05 | 6.786E-04 |
| 1.89 | 4.15 | 3.748E-01 | 6.101E-02 | 21.47 | 3.50 | 43.30 | 7.76 | .01289 | 8.435E-05 | 8.538E-05 | 6.734E-04 |
| 1.88 | 4.24 | 3.729E-01 | 6.077E-02 | 21.36 | 3.48 | 43.36 | 7.73 | .01298 | 8.328E-05 | 8.431E-05 | 6.680E-04 |
| 1.86 | 4.33 | 3.709E-01 | 6.051E-02 | 21.25 | 3.47 | 43.43 | 7.70 | .01309 | 8.218E-05 | 8.320E-05 | 6.623E-04 |
| 1.84 | 4.43 | 3.688E-01 | 6.024E-02 | 21.13 | 3.45 | 43.50 | 7.66 | .01321 | 8.103E-05 | 8.204E-05 | 6.565E-04 |
| 1.82 | 4.53 | 3.667E-01 | 5.997E-02 | 21.01 | 3.44 | 43.57 | 7.63 | .01333 | 7.984E-05 | 8.085E-05 | 6.505E-04 |
| 1.81 | 4.64 | 3.645E-01 | 5.968E-02 | 20.88 | 3.42 | 43.65 | 7.59 | .01345 | 7.861E-05 | 7.961E-05 | 6.442E-04 |
| 1.79 | 4.76 | 3.622E-01 | 5.938E-02 | 20.75 | 3.40 | 43.72 | 7.55 | .01359 | 7.733E-05 | 7.833E-05 | 6.378E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.77 | 4.87 | 3.599E-01 | 5.907E-02 | 20.62 | 3.38 | 43.89 | 7.51 | .01373 | 7.601E-05 | 7.788E-05 | 6.311E-04 |
| 1.76 | 5.00 | 3.574E-01 | 5.874E-02 | 20.48 | 3.37 | 43.88 | 7.47 | .01388 | 7.465E-05 | 7.563E-05 | 6.242E-04 |
| 1.74 | 5.13 | 3.549E-01 | 5.841E-02 | 20.34 | 3.35 | 43.96 | 7.43 | .01404 | 7.324E-05 | 7.422E-05 | 6.172E-04 |
| 1.73 | 5.27 | 3.524E-01 | 5.807E-02 | 20.19 | 3.33 | 44.04 | 7.39 | .01420 | 7.178E-05 | 7.275E-05 | 6.099E-04 |
| 1.71 | 5.42 | 3.497E-01 | 5.771E-02 | 20.04 | 3.31 | 44.13 | 7.34 | .01438 | 7.028E-05 | 7.124E-05 | 6.024E-04 |
| 1.70 | 5.57 | 3.470E-01 | 5.734E-02 | 19.88 | 3.29 | 44.22 | 7.29 | .01456 | 6.873E-05 | 6.968E-05 | 5.948E-04 |
| 1.68 | 5.74 | 3.443E-01 | 5.696E-02 | 19.72 | 3.26 | 44.30 | 7.25 | .01475 | 6.713E-05 | 6.807E-05 | 5.869E-04 |
| 1.67 | 5.91 | 3.414E-01 | 5.657E-02 | 19.55 | 3.24 | 44.39 | 7.20 | .01495 | 6.548E-05 | 6.641E-05 | 5.789E-04 |
| 1.65 | 6.09 | 3.385E-01 | 5.617E-02 | 19.39 | 3.22 | 44.49 | 7.15 | .01516 | 6.378E-05 | 6.478E-05 | 5.707E-04 |
| 1.64 | 6.29 | 3.355E-01 | 5.575E-02 | 19.22 | 3.19 | 44.58 | 7.09 | .01539 | 6.203E-05 | 6.293E-05 | 5.623E-04 |
| 1.63 | 6.50 | 3.325E-01 | 5.533E-02 | 19.05 | 3.17 | 44.67 | 7.04 | .01562 | 6.022E-05 | 6.112E-05 | 5.538E-04 |
| 1.61 | 6.72 | 3.294E-01 | 5.489E-02 | 18.87 | 3.15 | 44.77 | 6.98 | .01587 | 5.836E-05 | 5.924E-05 | 5.451E-04 |
| 1.60 | 6.96 | 3.262E-01 | 5.445E-02 | 18.69 | 3.12 | 44.87 | 6.93 | .01612 | 5.645E-05 | 5.731E-05 | 5.363E-04 |
| 1.59 | 7.22 | 3.230E-01 | 5.399E-02 | 18.51 | 3.09 | 44.96 | 6.87 | .01639 | 5.448E-05 | 5.533E-05 | 5.273E-04 |
| 1.57 | 7.50 | 3.197E-01 | 5.353E-02 | 18.32 | 3.07 | 45.06 | 6.81 | .01667 | 5.245E-05 | 5.328E-05 | 5.183E-04 |
| 1.56 | 7.80 | 3.164E-01 | 5.305E-02 | 18.13 | 3.04 | 45.16 | 6.75 | .01697 | 5.037E-05 | 5.118E-05 | 5.092E-04 |
| 1.55 | 8.12 | 3.131E-01 | 5.257E-02 | 17.94 | 3.01 | 45.26 | 6.69 | .01727 | 4.822E-05 | 4.902E-05 | 5.000E-04 |
| 1.54 | 8.48 | 3.098E-01 | 5.209E-02 | 17.75 | 2.98 | 45.35 | 6.63 | .01759 | 4.602E-05 | 4.679E-05 | 4.908E-04 |
| 1.52 | 8.86 | 3.064E-01 | 5.160E-02 | 17.56 | 2.96 | 45.45 | 6.56 | .01792 | 4.376E-05 | 4.451E-05 | 4.816E-04 |
| 1.51 | 9.29 | 3.030E-01 | 5.111E-02 | 17.36 | 2.93 | 45.55 | 6.50 | .01826 | 4.144E-05 | 4.216E-05 | 4.725E-04 |
| 1.50 | 9.75 | 2.997E-01 | 5.062E-02 | 17.17 | 2.90 | 45.64 | 6.44 | .01861 | 3.906E-05 | 3.975E-05 | 4.636E-04 |
| 1.49 | 10.26 | 2.964E-01 | 5.014E-02 | 16.98 | 2.87 | 45.73 | 6.38 | .01896 | 3.662E-05 | 3.728E-05 | 4.548E-04 |
| 1.48 | 10.83 | 2.932E-01 | 4.967E-02 | 16.80 | 2.85 | 45.82 | 6.32 | .01931 | 3.413E-05 | 3.475E-05 | 4.463E-04 |
| 1.47 | 11.47 | 2.902E-01 | 4.922E-02 | 16.63 | 2.82 | 45.91 | 6.26 | .01966 | 3.158E-05 | 3.217E-05 | 4.382E-04 |
| 1.46 | 12.19 | 2.873E-01 | 4.879E-02 | 16.46 | 2.80 | 45.99 | 6.21 | .02000 | 2.898E-05 | 2.954E-05 | 4.306E-04 |
| 1.44 | 13.00 | 2.847E-01 | 4.840E-02 | 16.31 | 2.77 | 46.06 | 6.16 | .02032 | 2.635E-05 | 2.686E-05 | 4.238E-04 |
| 1.43 | 13.93 | 2.824E-01 | 4.807E-02 | 16.18 | 2.75 | 46.12 | 6.11 | .02060 | 2.367E-05 | 2.414E-05 | 4.179E-04 |
| 1.42 | 15.00 | 2.805E-01 | 4.780E-02 | 16.07 | 2.74 | 46.17 | 6.08 | .02082 | 2.099E-05 | 2.140E-05 | 4.133E-04 |
| 1.41 | 16.25 | 2.793E-01 | 4.763E-02 | 16.00 | 2.73 | 46.20 | 6.06 | .02097 | 1.829E-05 | 1.866E-05 | 4.104E-04 |
| 1.40 | 17.73 | 2.790E-01 | 4.760E-02 | 15.98 | 2.73 | 46.21 | 6.06 | .02100 | 1.562E-05 | 1.594E-05 | 4.098E-04 |
| 1.39 | 19.50 | 2.798E-01 | 4.775E-02 | 16.03 | 2.74 | 46.19 | 6.07 | .02087 | 1.301E-05 | 1.327E-05 | 4.124E-04 |
| 1.38 | 21.67 | 2.822E-01 | 4.815E-02 | 16.17 | 2.75 | 46.12 | 6.13 | .02053 | 1.048E-05 | 1.069E-05 | 4.195E-04 |
| 1.37 | 24.37 | 2.871E-01 | 4.893E-02 | 16.45 | 2.80 | 45.99 | 6.22 | .01989 | 8.095E-06 | 8.248E-06 | 4.330E-04 |
| 1.36 | 27.86 | 2.954E-01 | 5.024E-02 | 16.92 | 2.88 | 45.75 | 6.39 | .01888 | 5.987E-06 | 6.013E-06 | 4.566E-04 |

RESULTS FOR TYPE II (O + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | R | M(R) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.60 | 2.60 | 5.780E-01 | 8.363E-02 | 33.12 | 4.79 | 41.88 | 10.64 | .00689 | 5.702E-05 | 5.739E-05 | 1.265E-03 |
| 2.57 | 2.64 | 5.823E-01 | 8.398E-02 | 33.37 | 4.81 | 41.76 | 10.68 | .00684 | 5.621E-05 | 5.657E-05 | 1.276E-03 |
| 2.53 | 2.67 | 5.866E-01 | 8.432E-02 | 33.61 | 4.83 | 41.64 | 10.73 | .00678 | 5.538E-05 | 5.574E-05 | 1.286E-03 |
| 2.50 | 2.71 | 5.910E-01 | 8.465E-02 | 33.86 | 4.85 | 41.52 | 10.77 | .00673 | 5.453E-05 | 5.488E-05 | 1.296E-03 |
| 2.47 | 2.75 | 5.953E-01 | 8.499E-02 | 34.11 | 4.87 | 41.40 | 10.81 | .00669 | 5.366E-05 | 5.400E-05 | 1.307E-03 |
| 2.44 | 2.79 | 5.996E-01 | 8.532E-02 | 34.35 | 4.89 | 41.28 | 10.85 | .00663 | 5.277E-05 | 5.310E-05 | 1.317E-03 |
| 2.41 | 2.83 | 6.039E-01 | 8.564E-02 | 34.60 | 4.91 | 41.16 | 10.90 | .00658 | 5.186E-05 | 5.218E-05 | 1.327E-03 |
| 2.38 | 2.87 | 6.082E-01 | 8.596E-02 | 34.85 | 4.93 | 41.03 | 10.94 | .00653 | 5.094E-05 | 5.125E-05 | 1.337E-03 |
| 2.35 | 2.91 | 6.125E-01 | 8.627E-02 | 35.10 | 4.94 | 40.91 | 10.98 | .00648 | 5.000E-05 | 5.030E-05 | 1.346E-03 |
| 2.32 | 2.95 | 6.169E-01 | 8.658E-02 | 35.34 | 4.96 | 40.78 | 11.01 | .00644 | 4.904E-05 | 4.934E-05 | 1.356E-03 |
| 2.29 | 3.00 | 6.212E-01 | 8.688E-02 | 35.59 | 4.98 | 40.66 | 11.05 | .00639 | 4.807E-05 | 4.836E-05 | 1.365E-03 |
| 2.27 | 3.05 | 6.256E-01 | 8.717E-02 | 35.84 | 4.99 | 40.53 | 11.09 | .00635 | 4.709E-05 | 4.737E-05 | 1.375E-03 |
| 2.24 | 3.10 | 6.299E-01 | 8.746E-02 | 36.09 | 5.01 | 40.40 | 11.13 | .00631 | 4.610E-05 | 4.637E-05 | 1.384E-03 |
| 2.22 | 3.15 | 6.343E-01 | 8.775E-02 | 36.34 | 5.03 | 40.27 | 11.16 | .00627 | 4.509E-05 | 4.536E-05 | 1.393E-03 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.19 | 3.20 | 6.387E-01 | 8.803E-02 | 36.60 | 5.04 | 40.14 | 11.20 | .00623 | 4.468E-05 | 4.434E-05 | 1.402E-03 |
| 2.17 | 3.25 | 6.431E-01 | 8.830E-02 | 36.85 | 5.06 | 40.01 | 11.23 | .00619 | 4.306E-05 | 4.331E-05 | 1.410E-03 |
| 2.14 | 3.31 | 6.476E-01 | 8.857E-02 | 37.10 | 5.07 | 39.88 | 11.27 | .00615 | 4.232E-05 | 4.227E-05 | 1.419E-03 |
| 2.12 | 3.36 | 6.520E-01 | 8.884E-02 | 37.36 | 5.09 | 39.74 | 11.30 | .00611 | 4.098E-05 | 4.122E-05 | 1.428E-03 |
| 2.10 | 3.42 | 6.565E-01 | 8.909E-02 | 37.62 | 5.10 | 39.61 | 11.33 | .00608 | 3.994E-05 | 4.017E-05 | 1.436E-03 |
| 2.07 | 3.48 | 6.610E-01 | 8.935E-02 | 37.87 | 5.12 | 39.47 | 11.37 | .00604 | 3.889E-05 | 3.911E-05 | 1.444E-03 |
| 2.05 | 3.55 | 6.656E-01 | 8.960E-02 | 38.14 | 5.13 | 39.33 | 11.40 | .00601 | 3.783E-05 | 3.805E-05 | 1.452E-03 |
| 2.03 | 3.61 | 6.702E-01 | 8.984E-02 | 38.40 | 5.15 | 39.19 | 11.43 | .00598 | 3.678E-05 | 3.698E-05 | 1.460E-03 |
| 2.01 | 3.68 | 6.748E-01 | 9.008E-02 | 38.66 | 5.16 | 39.04 | 11.46 | .00595 | 3.571E-05 | 3.591E-05 | 1.468E-03 |
| 1.99 | 3.75 | 6.794E-01 | 9.031E-02 | 38.93 | 5.17 | 38.90 | 11.49 | .00592 | 3.465E-05 | 3.485E-05 | 1.475E-03 |
| 1.97 | 3.82 | 6.841E-01 | 9.054E-02 | 39.20 | 5.19 | 38.75 | 11.52 | .00589 | 3.359E-05 | 3.378E-05 | 1.483E-03 |
| 1.95 | 3.90 | 6.889E-01 | 9.076E-02 | 39.47 | 5.20 | 38.60 | 11.55 | .00586 | 3.253E-05 | 3.271E-05 | 1.490E-03 |
| 1.93 | 3.98 | 6.937E-01 | 9.098E-02 | 39.74 | 5.21 | 38.45 | 11.57 | .00583 | 3.147E-05 | 3.164E-05 | 1.497E-03 |
| 1.91 | 4.06 | 6.985E-01 | 9.119E-02 | 40.02 | 5.22 | 38.29 | 11.60 | .00580 | 3.041E-05 | 3.057E-05 | 1.504E-03 |
| 1.89 | 4.15 | 7.035E-01 | 9.139E-02 | 40.31 | 5.24 | 38.13 | 11.63 | .00578 | 2.935E-05 | 2.951E-05 | 1.511E-03 |
| 1.88 | 4.24 | 7.084E-01 | 9.159E-02 | 40.59 | 5.25 | 37.97 | 11.65 | .00575 | 2.830E-05 | 2.845E-05 | 1.517E-03 |
| 1.86 | 4.33 | 7.135E-01 | 9.178E-02 | 40.88 | 5.26 | 37.80 | 11.68 | .00573 | 2.725E-05 | 2.740E-05 | 1.524E-03 |
| 1.84 | 4.43 | 7.187E-01 | 9.197E-02 | 41.18 | 5.27 | 37.63 | 11.70 | .00571 | 2.621E-05 | 2.635E-05 | 1.530E-03 |
| 1.82 | 4.53 | 7.239E-01 | 9.214E-02 | 41.48 | 5.28 | 37.46 | 11.72 | .00569 | 2.517E-05 | 2.531E-05 | 1.536E-03 |
| 1.81 | 4.64 | 7.293E-01 | 9.232E-02 | 41.78 | 5.29 | 37.28 | 11.74 | .00566 | 2.415E-05 | 2.428E-05 | 1.542E-03 |
| 1.79 | 4.76 | 7.347E-01 | 9.248E-02 | 42.10 | 5.30 | 37.10 | 11.77 | .00564 | 2.313E-05 | 2.325E-05 | 1.547E-03 |
| 1.77 | 4.87 | 7.403E-01 | 9.263E-02 | 42.42 | 5.31 | 36.91 | 11.78 | .00563 | 2.212E-05 | 2.223E-05 | 1.552E-03 |
| 1.76 | 5.00 | 7.461E-01 | 9.278E-02 | 42.75 | 5.32 | 36.72 | 11.80 | .00561 | 2.112E-05 | 2.123E-05 | 1.557E-03 |
| 1.74 | 5.13 | 7.520E-01 | 9.292E-02 | 43.08 | 5.32 | 36.52 | 11.82 | .00559 | 2.013E-05 | 2.024E-05 | 1.562E-03 |
| 1.73 | 5.27 | 7.580E-01 | 9.305E-02 | 43.43 | 5.33 | 36.31 | 11.84 | .00558 | 1.915E-05 | 1.925E-05 | 1.566E-03 |
| 1.71 | 5.42 | 7.643E-01 | 9.316E-02 | 43.79 | 5.34 | 36.09 | 11.85 | .00556 | 1.819E-05 | 1.829E-05 | 1.570E-03 |
| 1.70 | 5.57 | 7.708E-01 | 9.327E-02 | 44.16 | 5.34 | 35.87 | 11.87 | .00555 | 1.724E-05 | 1.733E-05 | 1.574E-03 |
| 1.68 | 5.74 | 7.775E-01 | 9.336E-02 | 44.55 | 5.35 | 35.63 | 11.88 | .00554 | 1.631E-05 | 1.639E-05 | 1.577E-03 |
| 1.67 | 5.91 | 7.845E-01 | 9.343E-02 | 44.95 | 5.35 | 35.39 | 11.89 | .00553 | 1.539E-05 | 1.547E-05 | 1.579E-03 |
| 1.65 | 6.09 | 7.916E-01 | 9.349E-02 | 45.37 | 5.36 | 35.13 | 11.89 | .00552 | 1.449E-05 | 1.456E-05 | 1.581E-03 |
| 1.64 | 6.29 | 7.995E-01 | 9.352E-02 | 45.81 | 5.36 | 34.85 | 11.90 | .00552 | 1.360E-05 | 1.367E-05 | 1.582E-03 |
| 1.63 | 6.50 | 8.076E-01 | 9.354E-02 | 46.27 | 5.36 | 34.56 | 11.90 | .00552 | 1.273E-05 | 1.280E-05 | 1.583E-03 |
| 1.61 | 6.72 | 8.162E-01 | 9.352E-02 | 46.76 | 5.36 | 34.25 | 11.90 | .00552 | 1.189E-05 | 1.195E-05 | 1.582E-03 |
| 1.60 | 6.96 | 8.252E-01 | 9.347E-02 | 47.28 | 5.36 | 33.92 | 11.89 | .00553 | 1.106E-05 | 1.112E-05 | 1.580E-03 |
| 1.59 | 7.22 | 8.350E-01 | 9.339E-02 | 47.84 | 5.35 | 33.56 | 11.88 | .00554 | 1.025E-05 | 1.030E-05 | 1.577E-03 |
| 1.57 | 7.50 | 8.454E-01 | 9.324E-02 | 48.44 | 5.34 | 33.17 | 11.86 | .00555 | 9.467E-06 | 9.516E-06 | 1.573E-03 |
| 1.56 | 7.80 | 8.567E-01 | 9.303E-02 | 49.09 | 5.33 | 32.75 | 11.84 | .00558 | 8.705E-06 | 8.751E-06 | 1.566E-03 |
| 1.55 | 8.12 | 8.691E-01 | 9.275E-02 | 49.79 | 5.31 | 32.25 | 11.80 | .00561 | 7.968E-06 | 8.010E-06 | 1.556E-03 |
| 1.54 | 8.48 | 8.826E-01 | 9.237E-02 | 50.57 | 5.29 | 31.76 | 11.75 | .00566 | 7.255E-06 | 7.294E-06 | 1.544E-03 |
| 1.52 | 8.86 | 8.977E-01 | 9.187E-02 | 51.43 | 5.26 | 31.17 | 11.69 | .00572 | 6.569E-06 | 6.604E-06 | 1.527E-03 |
| 1.51 | 9.29 | 9.145E-01 | 9.119E-02 | 52.40 | 5.23 | 30.51 | 11.60 | .00580 | 5.909E-06 | 5.941E-06 | 1.504E-03 |
| 1.50 | 9.75 | 9.336E-01 | 9.030E-02 | 53.49 | 5.17 | 29.75 | 11.49 | .00592 | 5.277E-06 | 5.307E-06 | 1.475E-03 |
| 1.49 | 10.26 | 9.555E-01 | 8.910E-02 | 54.75 | 5.10 | 28.86 | 11.33 | .00608 | 4.675E-06 | 4.702E-06 | 1.436E-03 |
| 1.48 | 10.83 | 9.810E-01 | 8.747E-02 | 56.21 | 5.01 | 27.81 | 11.13 | .00631 | 4.104E-06 | 4.128E-06 | 1.384E-03 |
| 1.47 | 11.47 | 1.011E+00 | 8.522E-02 | 57.94 | 4.88 | 26.54 | 10.84 | .00664 | 3.564E-06 | 3.586E-06 | 1.314E-03 |
| 1.45 | 12.19 | 1.048E+00 | 8.204E-02 | 60.05 | 4.70 | 24.96 | 10.44 | .00716 | 3.056E-06 | 3.077E-06 | 1.218E-03 |
| 1.44 | 13.00 | 1.09[illegible]E+00 | 7.741E-02 | 62.70 | 4.44 | 22.93 | 9.85 | .00804 | 2.584E-06 | 2.603E-06 | 1.084E-03 |
| 1.43 | 13.93 | 1.155E+00 | 7.028E-02 | 66.18 | 4.03 | 20.19 | 8.94 | .00974 | 2.146E-06 | 2.165E-06 | 8.934E-04 |
| 1.42 | 15.00 | 1.242E+00 | 5.829E-02 | 71.13 | 3.34 | 16.17 | 7.42 | .01409 | 1.742E-06 | 1.765E-06 | 6.146E-04 |
| 1.41 | 16.25 | 1.390E+00 | 3.260E-02 | 80.01 | 1.87 | 8.67 | 4.15 | .04379 | 1.347E-06 | 1.404E-06 | 1.922E-04 |

PHASE MATCHING CUTS OFF AT SIGNAL= 1.403 AND TOLER= 17.727

PHASE MATCHING CUTS OFF AT SIGNAL= 1.393 AND TOLER= 19.500

PHASE MATCHING CUTS OFF AT SIGNAL= 1.383 AND TOLER= 21.667

PHASE MATCHING CUTS OFF AT SIGNAL= 1.373 AND IDLER= 24.375

PHASE MATCHING CUTS OFF AT SIGNAL= 1.364 AND IDLER= 27.857

RESULTS FOR TYPE II (E + O = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | R | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.60 | 2.60 | 5.780E-01 | 8.363E-02 | 33.12 | 4.79 | 41.88 | 10.64 | .00689 | 5.702E-05 | 5.739E-05 | 1.265E-03 |
| 2.57 | 2.64 | 5.737E-01 | 8.327E-02 | 32.87 | 4.77 | 41.99 | 10.59 | .00695 | 5.781E-05 | 5.819E-05 | 1.254E-03 |
| 2.53 | 2.67 | 5.694E-01 | 8.291E-02 | 32.63 | 4.75 | 42.11 | 10.55 | .00701 | 5.857E-05 | 5.896E-05 | 1.243E-03 |
| 2.50 | 2.71 | 5.651E-01 | 8.254E-02 | 32.38 | 4.73 | 42.23 | 10.50 | .00708 | 5.931E-05 | 5.970E-05 | 1.232E-03 |
| 2.47 | 2.75 | 5.608E-01 | 8.217E-02 | 32.13 | 4.71 | 42.34 | 10.45 | .00714 | 6.002E-05 | 6.043E-05 | 1.221E-03 |
| 2.44 | 2.79 | 5.565E-01 | 8.179E-02 | 31.88 | 4.69 | 42.46 | 10.41 | .00720 | 6.071E-05 | 6.112E-05 | 1.210E-03 |
| 2.41 | 2.83 | 5.521E-01 | 8.141E-02 | 31.64 | 4.66 | 42.57 | 10.36 | .00727 | 6.137E-05 | 6.179E-05 | 1.199E-03 |
| 2.38 | 2.87 | 5.478E-01 | 8.102E-02 | 31.39 | 4.64 | 42.68 | 10.31 | .00734 | 6.200E-05 | 6.242E-05 | 1.187E-03 |
| 2.35 | 2.91 | 5.435E-01 | 8.062E-02 | 31.14 | 4.62 | 42.80 | 10.26 | .00741 | 6.260E-05 | 6.303E-05 | 1.176E-03 |
| 2.32 | 2.95 | 5.391E-01 | 8.022E-02 | 30.89 | 4.60 | 42.91 | 10.21 | .00749 | 6.316E-05 | 6.361E-05 | 1.164E-03 |
| 2.29 | 3.00 | 5.348E-01 | 7.981E-02 | 30.64 | 4.57 | 43.02 | 10.15 | .00756 | 6.370E-05 | 6.416E-05 | 1.152E-03 |
| 2.27 | 3.05 | 5.304E-01 | 7.939E-02 | 30.39 | 4.55 | 43.13 | 10.10 | .00764 | 6.421E-05 | 6.467E-05 | 1.140E-03 |
| 2.24 | 3.10 | 5.260E-01 | 7.897E-02 | 30.14 | 4.52 | 43.24 | 10.05 | .00772 | 6.468E-05 | 6.515E-05 | 1.128E-03 |
| 2.22 | 3.15 | 5.216E-01 | 7.854E-02 | 29.89 | 4.50 | 43.35 | 9.99 | .00781 | 6.511E-05 | 6.559E-05 | 1.116E-03 |
| 2.19 | 3.20 | 5.172E-01 | 7.811E-02 | 29.63 | 4.48 | 43.46 | 9.94 | .00790 | 6.552E-05 | 6.600E-05 | 1.104E-03 |
| 2.17 | 3.25 | 5.128E-01 | 7.767E-02 | 29.38 | 4.45 | 43.57 | 9.88 | .00798 | 6.588E-05 | 6.636E-05 | 1.091E-03 |
| 2.14 | 3.31 | 5.084E-01 | 7.722E-02 | 29.13 | 4.42 | 43.68 | 9.82 | .00808 | 6.621E-05 | 6.671E-05 | 1.079E-03 |
| 2.12 | 3.36 | 5.039E-01 | 7.676E-02 | 28.87 | 4.40 | 43.78 | 9.77 | .00817 | 6.649E-05 | 6.700E-05 | 1.066E-03 |
| 2.10 | 3.42 | 4.995E-01 | 7.630E-02 | 28.62 | 4.37 | 43.89 | 9.71 | .00827 | 6.674E-05 | 6.726E-05 | 1.053E-03 |
| 2.07 | 3.49 | 4.950E-01 | 7.583E-02 | 28.36 | 4.34 | 44.00 | 9.65 | .00837 | 6.695E-05 | 6.747E-05 | 1.040E-03 |
| 2.05 | 3.55 | 4.905E-01 | 7.536E-02 | 28.10 | 4.32 | 44.11 | 9.59 | .00848 | 6.711E-05 | 6.765E-05 | 1.027E-03 |
| 2.03 | 3.61 | 4.860E-01 | 7.487E-02 | 27.86 | 4.29 | 44.21 | 9.53 | .00859 | 6.723E-05 | 6.778E-05 | 1.014E-03 |
| 2.01 | 3.68 | 4.814E-01 | 7.438E-02 | 27.59 | 4.26 | 44.32 | 9.46 | .00870 | 6.731E-05 | 6.786E-05 | 1.001E-03 |
| 1.99 | 3.75 | 4.769E-01 | 7.389E-02 | 27.32 | 4.23 | 44.42 | 9.40 | .00882 | 6.734E-05 | 6.790E-05 | 9.879E-04 |
| 1.97 | 3.82 | 4.723E-01 | 7.338E-02 | 27.05 | 4.20 | 44.53 | 9.34 | .00894 | 6.732E-05 | 6.789E-05 | 9.741E-04 |
| 1.95 | 3.90 | 4.677E-01 | 7.287E-02 | 26.80 | 4.17 | 44.63 | 9.27 | .00906 | 6.726E-05 | 6.784E-05 | 9.605E-04 |
| 1.93 | 3.99 | 4.631E-01 | 7.235E-02 | 26.54 | 4.15 | 44.73 | 9.20 | .00919 | 6.715E-05 | 6.773E-05 | 9.468E-04 |
| 1.91 | 4.06 | 4.585E-01 | 7.182E-02 | 26.27 | 4.11 | 44.84 | 9.14 | .00933 | 6.699E-05 | 6.758E-05 | 9.330E-04 |
| 1.89 | 4.15 | 4.539E-01 | 7.128E-02 | 26.00 | 4.08 | 44.94 | 9.07 | .00947 | 6.678E-05 | 6.737E-05 | 9.191E-04 |
| 1.88 | 4.24 | 4.492E-01 | 7.074E-02 | 25.74 | 4.05 | 45.04 | 9.00 | .00961 | 6.651E-05 | 6.712E-05 | 9.051E-04 |
| 1.86 | 4.33 | 4.445E-01 | 7.018E-02 | 25.47 | 4.02 | 45.14 | 8.93 | .00976 | 6.620E-05 | 6.681E-05 | 8.910E-04 |
| 1.84 | 4.43 | 4.398E-01 | 6.962E-02 | 25.20 | 3.99 | 45.24 | 8.86 | .00992 | 6.583E-05 | 6.644E-05 | 8.769E-04 |
| 1.82 | 4.53 | 4.350E-01 | 6.905E-02 | 24.92 | 3.96 | 45.34 | 8.78 | .01008 | 6.540E-05 | 6.602E-05 | 8.626E-04 |
| 1.81 | 4.64 | 4.303E-01 | 6.848E-02 | 24.65 | 3.92 | 45.44 | 8.71 | .01025 | 6.492E-05 | 6.555E-05 | 8.482E-04 |
| 1.79 | 4.76 | 4.255E-01 | 6.789E-02 | 24.38 | 3.89 | 45.54 | 8.64 | .01043 | 6.438E-05 | 6.501E-05 | 8.337E-04 |
| 1.77 | 4.87 | 4.206E-01 | 6.729E-02 | 24.10 | 3.86 | 45.64 | 8.56 | .01061 | 6.378E-05 | 6.442E-05 | 8.192E-04 |
| 1.76 | 5.00 | 4.158E-01 | 6.669E-02 | 23.82 | 3.82 | 45.74 | 8.49 | .01080 | 6.312E-05 | 6.376E-05 | 846E-04 |
| 1.74 | 5.13 | 4.109E-01 | 6.608E-02 | 23.54 | 3.79 | 45.84 | 8.41 | .01100 | 6.240E-05 | 6.305E-05 | 899E-04 |
| 1.73 | 5.27 | 4.060E-01 | 6.546E-02 | 23.26 | 3.75 | 45.93 | 8.33 | .01121 | 6.161E-05 | 6.227E-05 | 7. 51E-04 |
| 1.71 | 5.42 | 4.011E-01 | 6.483E-02 | 22.98 | 3.71 | 46.03 | 8.25 | .01142 | 6.076E-05 | 6.142E-05 | .603E-04 |
| 1.70 | 5.57 | 3.962E-01 | 6.419E-02 | 22.70 | 3.68 | 46.13 | 8.17 | .01165 | 5.985E-05 | 6.051E-05 | 7.454E-04 |
| 1.68 | 5.74 | 3.912E-01 | 6.354E-02 | 22.42 | 3.64 | 46.22 | 8.08 | .01188 | 5.887E-05 | 5.953E-05 | 7.304E-04 |
| 1.67 | 5.91 | 3.862E-01 | 6.289E-02 | 22.13 | 3.60 | 46.32 | 8.00 | .01213 | 5.782E-05 | 5.849E-05 | 7.155E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.65 | 6.09 | 3.812E-01 | 6.223E-02 | 21.84 | 3.57 | 46.41 | 7.92 | .01239 | 5.671E-05 | 5.737E-05 | 7.004E-04 |
| 1.64 | 6.29 | 3.752E-01 | 6.155E-02 | 21.55 | 3.53 | 46.50 | 7.83 | .01266 | 5.552E-05 | 5.618E-05 | 6.854E-04 |
| 1.63 | 6.50 | 3.712E-01 | 6.088E-02 | 21.27 | 3.49 | 46.60 | 7.74 | .01294 | 5.426E-05 | 5.492E-05 | 6.704E-04 |
| 1.61 | 6.72 | 3.661E-01 | 6.019E-02 | 20.98 | 3.45 | 46.69 | 7.66 | .01323 | 5.292E-05 | 5.359E-05 | 6.553E-04 |
| 1.60 | 6.96 | 3.610E-01 | 5.950E-02 | 20.68 | 3.41 | 46.78 | 7.57 | .01354 | 5.152E-05 | 5.218E-05 | 6.403E-04 |
| 1.59 | 7.22 | 3.559E-01 | 5.880E-02 | 20.39 | 3.37 | 46.87 | 7.48 | .01386 | 5.003E-05 | 5.069E-05 | 6.253E-04 |
| 1.57 | 7.50 | 3.509E-01 | 5.809E-02 | 20.10 | 3.33 | 46.95 | 7.39 | .01419 | 4.847E-05 | 4.912E-05 | 6.104E-04 |
| 1.56 | 7.80 | 3.458E-01 | 5.738E-02 | 19.81 | 3.29 | 47.04 | 7.30 | .01454 | 4.683E-05 | 4.747E-05 | 5.95[illegible]-04 |
| 1.55 | 8.12 | 3.407E-01 | 5.667E-02 | 19.52 | 3.25 | 47.13 | 7.21 | .01490 | 4.511E-05 | 4.575E-05 | 5.809E-04 |
| 1.54 | 8.48 | 3.357E-01 | 5.595E-02 | 19.23 | 3.21 | 47.21 | 7.12 | .01528 | 4.331E-05 | 4.394E-05 | 5.663E-04 |
| 1.52 | 8.86 | 3.307E-01 | 5.524E-02 | 18.95 | 3.16 | 47.29 | 7.03 | .01567 | 4.142E-05 | 4.204E-05 | 5.528E-04 |
| 1.51 | 9.29 | 3.257E-01 | 5.453E-02 | 18.66 | 3.12 | 47.37 | 6.94 | .01607 | 3.946E-05 | 4.006E-05 | 5.379E-04 |
| 1.50 | 9.75 | 3.209E-01 | 5.392E-02 | 18.38 | 3.08 | 47.45 | 6.85 | .01649 | 3.741E-05 | 3.800E-05 | 5.241E-04 |
| 1.49 | 10.26 | 3.161E-01 | 5.313E-02 | 18.11 | 3.04 | 47.52 | 6.76 | .01692 | 3.528E-05 | 3.585E-05 | 5.106E-04 |
| 1.48 | 10.83 | 3.115E-01 | 5.245E-02 | 17.85 | 3.01 | 47.59 | 6.67 | .01735 | 3.307E-05 | 3.362E-05 | 4.977E-04 |
| 1.47 | 11.47 | 3.070E-01 | 5.180E-02 | 17.59 | 2.97 | 47.66 | 6.59 | .01779 | 3.079E-05 | 3.131E-05 | 4.853E-04 |
| 1.46 | 12.19 | 3.027E-01 | 5.117E-02 | 17.35 | 2.93 | 47.73 | 6.51 | .01822 | 2.843E-05 | 2.892E-05 | 4.737E-04 |
| 1.44 | 13.00 | 2.988E-01 | 5.059E-02 | 17.12 | 2.90 | 47.78 | 6.44 | .01863 | 2.600E-05 | 2.646E-05 | 4.638E-04 |
| 1.43 | 13.93 | 2.952E-01 | 5.006E-02 | 16.92 | 2.87 | 47.84 | 6.37 | .01902 | 2.352E-05 | 2.394E-05 | 4.534E-04 |
| 1.42 | 15.00 | 2.922E-0[illegible] | 4.961E-02 | 16.74 | 2.84 | 47.88 | 6.31 | .01936 | 2.098E-05 | 2.137E-05 | 4.453E[illegible]04 |
| 1.41 | 16.25 | 2.898E-01 | 4.926E-02 | 16.60 | 2.82 | 47.92 | 6.27 | .01963 | 1.842E-05 | 1.877E-05 | 4.390E-04 |
| 1.40 | 17.73 | 2.883E-01 | 4.905E-02 | 16.52 | 2.81 | 47.94 | 6.24 | .01980 | 1.585E-05 | 1.615E-05 | 4.352E-04 |
| 1.39 | 19.50 | 2.880E-01 | 4.902E-02 | 16.50 | 2.81 | 47.94 | 6.24 | .01982 | 1.331E-05 | 1.356E-05 | 4.347E-04 |
| 1.38 | 21.67 | 2.893E-01 | 4.925E-02 | 16.58 | 2.82 | 47.92 | 6.27 | .01964 | 1.082E-05 | 1.103E-05 | 4.388E-04 |
| 1.37 | 24.37 | 2.930E-01 | 4.935E-02 | 16.79 | 2.86 | 47.87 | 6.34 | .01918 | 8.455E-06 | 8.609E-06 | 4.494E-04 |
| 1.36 | 27.86 | 3.001E-01 | 5.097E-02 | 17.19 | 2.92 | 47.77 | 6.48 | .01836 | 6.256E-06 | 6.365E-06 | 4.699E-04 |

PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO

CINNABAR

PHASE MATCHING FOR POSITIVE BIREFRINGENT CRYSTAL

PUMP WAVELENGTH(MICRONS)= 1.830

NONLINEAR COEFFICIENTS(X10 E12 M/V)= 50.000 0.000 -0.000 -0.000 -0.000

CUTOFF WAVELENGTH= 30.000

RESULTS FOR TYPE I (E + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.66 | 3.66 | 2.985E-01 | 4.924E-02 | 17.10 | 2.82 | 45.67 | 5.26 | .02768 | 9.938E-05 | 1.020E-04 | 4.363E-04 |
| 3.[illegible] | 3.71 | 2.985E-01 | 4.925E-02 | 17.10 | 2.82 | 45.68 | 5.26 | .02768 | 9.931E-05 | 1.020E-04 | 4.364E-04 |
| 3.56 | 3.76 | 2.985E-01 | 4.925E-02 | 17.10 | 2.82 | 45.68 | 5.26 | .02767 | 9.920E-05 | 1.018E-04 | 4.365E-04 |
| 3.52 | 3.81 | 2.984E-01 | 4.925E-02 | 17.10 | 2.82 | 45.68 | 5.26 | .02768 | 9.904E-05 | 1.017E-04 | 4.364E-04 |
| 3.47 | 3.87 | 2.983E-01 | 4.924E-02 | 17.09 | 2.82 | 45.68 | 5.26 | .02768 | 9.884E-05 | 1.015E-04 | 4.363E-04 |
| 3.43 | 3.92 | 2.981E-01 | 4.923E-02 | 17.08 | 2.82 | 45.69 | 5.26 | .02770 | 9.858E-05 | 1.012E-04 | 4.361E-04 |
| 3.39 | 3.98 | 2.980E-01 | 4.921E-02 | 17.07 | 2.82 | 45.69 | 5.25 | .02771 | 9.828E-05 | 1.009E-04 | 4.358E-04 |
| 3.35 | 4.04 | 2.978E-01 | 4.919E-02 | 17.06 | 2.82 | 45.70 | 5.25 | .02774 | 9.793E-05 | 1.005E-04 | 4.355E-04 |
| 3.31 | 4.10 | 2.975E-01 | 4.917E-02 | 17.05 | 2.82 | 45.70 | 5.25 | .02776 | 9.753E-05 | 1.001E-04 | 4.350E-04 |
| 3.27 | 4.16 | 2.973E-01 | 4.914E-02 | 17.03 | 2.82 | 45.71 | 5.25 | .02780 | 9.708E-05 | 9.967E-05 | 4.345E-04 |
| 3.23 | 4.22 | 2.970E-01 | 4.910E-02 | 17.02 | 2.81 | 45.72 | 5.24 | .02784 | 9.658E-05 | 9.917E-05 | 4.339E-04 |
| 3.19 | 4.29 | 2.967E-01 | 4.906E-02 | 17.00 | 2.81 | 45.73 | 5.24 | .02788 | 9.604E-05 | 9.861E-05 | 4.332E-04 |
| 3.16 | 4.36 | 2.963E-01 | 4.902E-02 | 16.98 | 2.81 | 45.74 | 5.23 | .02793 | 9.544E-05 | 9.801E-05 | 4.324E-04 |
| 3.12 | 4.43 | 2.959E-01 | 4.897E-02 | 16.96 | 2.81 | 45.75 | 5.23 | .02798 | 9.480E-05 | 9.735E-05 | 4.315E-04 |
| 3.08 | 4.50 | 2.955E-01 | 4.892E-02 | 16.93 | 2.80 | 45.76 | 5.22 | .02804 | 9.411E-05 | 9.665E-05 | 4.306E-04 |
| 3.05 | 4.57 | 2.951E-01 | 4.886E-02 | 16.91 | 2.80 | 45.77 | 5.22 | .02810 | 9.337E-05 | 9.589E-05 | 4.296E-04 |
| 3.02 | 4.65 | 2.946E-01 | 4.880E-02 | 16.88 | 2.80 | 45.78 | 5.21 | .02817 | 9.258E-05 | 9.509E-05 | 4.285E-04 |
| 2.98 | 4.73 | 2.941E-01 | 4.873E-02 | 16.85 | 2.79 | 45.80 | 5.20 | .02825 | 9.174E-05 | 9.423E-05 | 4.274E-04 |
| 2.95 | 4.82 | 2.936E-01 | 4.866E-02 | 16.82 | 2.79 | 45.81 | 5.20 | .02833 | 9.085E-05 | 9.333E-05 | 4.261E-04 |
| 2.92 | 4.90 | 2.930E-01 | 4.859E-02 | 16.79 | 2.79 | 45.83 | 5.19 | .02841 | 8.991E-05 | 9.237E-05 | 4.248E-04 |
| 2.89 | 4.99 | 2.925E-01 | 4.851E-02 | 16.76 | 2.78 | 45.84 | 5.18 | .02850 | 8.893E-05 | 9.137E-05 | 4.235E-04 |
| 2.86 | 5.08 | 2.918E-01 | 4.843E-02 | 16.72 | 2.77 | 45.86 | 5.17 | .02859 | 8.789E-05 | 9.031E-05 | 4.220E-04 |
| 2.83 | 5.18 | 2.912E-01 | 4.834E-02 | 16.69 | 2.77 | 45.88 | 5.16 | .02869 | 8.680E-05 | 8.920E-05 | 4.206E-04 |
| 2.80 | 5.28 | 2.906E-01 | 4.825E-02 | 16.65 | 2.76 | 45.90 | 5.15 | .02880 | 8.567E-05 | 8.804E-05 | 4.190E-04 |
| 2.77 | 5.38 | 2.899E-01 | 4.816E-02 | 16.61 | 2.76 | 45.91 | 5.14 | .02891 | 8.448E-05 | 8.683E-05 | 4.174E-04 |
| 2.75 | 5.49 | 2.892E-01 | 4.806E-02 | 16.57 | 2.75 | 45.93 | 5.13 | .02902 | 8.324E-05 | 8.557E-05 | 4.157E-04 |
| 2.72 | 5.60 | 2.885E-01 | 4.796E-02 | 16.53 | 2.75 | 45.95 | 5.12 | .02914 | 8.196E-05 | 8.425E-05 | 4.140E-04 |
| 2.69 | 5.72 | 2.877E-01 | 4.786E-02 | 16.49 | 2.74 | 45.97 | 5.11 | .02926 | 8.062E-05 | 8.289E-05 | 4.122E-04 |
| 2.67 | 5.84 | 2.870E-01 | 4.775E-02 | 16.44 | 2.74 | 45.99 | 5.10 | .02939 | 7.923E-05 | 8.147E-05 | 4.103E-04 |
| 2.64 | 5.97 | 2.862E-01 | 4.764E-02 | 16.40 | 2.73 | 46.02 | 5.09 | .02952 | 7.779E-05 | 8.000E-05 | 4.085E-04 |
| 2.61 | 6.10 | 2.854E-01 | 4.753E-02 | 16.35 | 2.72 | 46.04 | 5.07 | .02965 | 7.630E-05 | 7.848E-05 | 4.066E-04 |
| 2.59 | 6.24 | 2.846E-01 | 4.742E-02 | 16.31 | 2.72 | 46.06 | 5.06 | .02979 | 7.476E-05 | 7.691E-05 | 4.046E-04 |
| 2.57 | 6.38 | 2.838E-01 | 4.730E-02 | 16.26 | 2.71 | 46.08 | 5.05 | .02993 | 7.317E-05 | 7.528E-05 | 4.026E-04 |
| 2.54 | 6.54 | 2.830E-01 | 4.719E-02 | 16.21 | 2.70 | 46.10 | 5.04 | .03008 | 7.153E-05 | 7.360E-05 | 4.007E-04 |
| 2.52 | 6.70 | 2.821E-01 | 4.707E-02 | 16.16 | 2.70 | 46.12 | 5.02 | .03022 | 6.984E-05 | 7.187E-05 | 3.987E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.50 | 6.86 | 2.813E-01 | 4.695E-02 | 16.12 | 2.69 | 46.15 | 5.01 | .03037 | 6.810E-05 | 7.009E-05 | 3.966E-04 |
| 2.47 | 7.04 | 2.805E-01 | 4.683E-02 | 16.07 | 2.68 | 46.17 | 5.00 | .03052 | 6.631E-05 | 6.826E-05 | 3.946E-04 |
| 2.45 | 7.22 | 2.796E-01 | 4.671E-02 | 16.02 | 2.68 | 46.19 | 4.99 | .03067 | 6.447E-05 | 6.638E-05 | 3.926E-04 |
| 2.43 | 7.42 | 2.788E-01 | 4.659E-02 | 15.97 | 2.67 | 46.21 | 4.97 | .03083 | 6.258E-05 | 6.444E-05 | 3.907E-04 |
| 2.41 | 7.62 | 2.780E-01 | 4.648E-02 | 15.93 | 2.66 | 46.23 | 4.96 | .03097 | 6.065E-05 | 6.246E-05 | 3.887E-04 |
| 2.39 | 7.84 | 2.772E-01 | 4.637E-02 | 15.88 | 2.66 | 46.26 | 4.95 | .03112 | 5.866E-05 | 6.043E-05 | 3.868E-04 |
| 2.37 | 8.07 | 2.764E-01 | 4.626E-02 | 15.84 | 2.65 | 46.28 | 4.94 | .03126 | 5.664E-05 | 5.834E-05 | 3.850E-04 |
| 2.35 | 8.32 | 2.757E-01 | 4.615E-02 | 15.79 | 2.64 | 46.30 | 4.93 | .03140 | 5.456E-05 | 5.622E-05 | 3.833E-04 |
| 2.33 | 8.58 | 2.750E-01 | 4.605E-02 | 15.75 | 2.64 | 46.31 | 4.92 | .03153 | 5.245E-05 | 5.404E-05 | 3.816E-04 |
| 2.31 | 8.85 | 2.743E-01 | 4.596E-02 | 15.72 | 2.63 | 46.33 | 4.91 | .03166 | 5.029E-05 | 5.183E-05 | 3.801E-04 |
| 2.29 | 9.15 | 2.737E-01 | 4.588E-02 | 15.68 | 2.63 | 46.35 | 4.90 | .03177 | 4.810E-05 | 4.957E-05 | 3.787E-04 |
| 2.27 | 9.47 | 2.732E-01 | 4.580E-02 | 15.65 | 2.62 | 46.36 | 4.89 | .03187 | 4.586E-05 | 4.727E-05 | 3.775E-04 |
| 2.25 | 9.80 | 2.727E-01 | 4.574E-02 | 15.63 | 2.62 | 46.37 | 4.88 | .03195 | 4.360E-05 | 4.494E-05 | 3.765E-04 |
| 2.23 | 10.17 | 2.724E-01 | 4.570E-02 | 15.61 | 2.62 | 46.38 | 4.88 | .03201 | 4.130E-05 | 4.258E-05 | 3.757E-04 |
| 2.21 | 10.56 | 2.721E-01 | 4.567E-02 | 15.59 | 2.62 | 46.39 | 4.88 | .03205 | 3.898E-05 | 4.019E-05 | 3.753E-04 |
| 2.20 | 10.98 | 2.720E-01 | 4.566E-02 | 15.59 | 2.62 | 46.39 | 4.87 | .03206 | 3.664E-05 | 3.778E-05 | 3.752E-04 |
| 2.18 | 11.44 | 2.721E-01 | 4.568E-02 | 15.59 | 2.62 | 46.39 | 4.88 | .03204 | 3.428E-05 | 3.535E-05 | 3.754E-04 |
| 2.16 | 11.93 | 2.723E-01 | 4.572E-02 | 15.60 | 2.62 | 46.38 | 4.88 | .03197 | 3.192E-05 | 3.290E-05 | 3.762E-04 |
| 2.14 | 12.48 | 2.727E-01 | 4.580E-02 | 15.63 | 2.62 | 46.37 | 4.89 | .03187 | 2.955E-05 | 3.046E-05 | 3.775E-04 |
| 2.13 | 13.07 | 2.735E-01 | 4.592E-02 | 15.67 | 2.63 | 46.35 | 4.90 | .03171 | 2.719E-05 | 2.802E-05 | 3.795E-04 |
| 2.11 | 13.72 | 2.745E-01 | 4.609E-02 | 15.73 | 2.64 | 46.33 | 4.92 | .03148 | 2.484E-05 | 2.559E-05 | 3.822E-04 |
| 2.10 | 14.45 | 2.758E-01 | 4.631E-02 | 15.80 | 2.65 | 46.29 | 4.94 | .03119 | 2.252E-05 | 2.320E-05 | 3.859E-04 |
| 2.08 | 15.25 | 2.776E-01 | 4.660E-02 | 15.91 | 2.67 | 46.24 | 4.97 | .03082 | 2.023E-05 | 2.084E-05 | 3.907E-04 |
| 2.06 | 16.15 | 2.799E-01 | 4.696E-02 | 16.04 | 2.69 | 46.18 | 5.01 | .03036 | 1.800E-05 | 1.853E-05 | 3.969E-04 |
| 2.05 | 17.16 | 2.829E-01 | 4.742E-02 | 16.21 | 2.72 | 46.11 | 5.06 | .02979 | 1.583E-05 | 1.620E-05 | 4.047E-04 |
| 2.03 | 18.30 | 2.865E-01 | 4.799E-02 | 16.42 | 2.75 | 46.01 | 5.12 | .02910 | 1.374E-05 | 1.412E-05 | 4.145E-04 |
| 2.02 | 19.61 | 2.911E-01 | 4.870E-02 | 16.68 | 2.79 | 45.88 | 5.20 | .02828 | 1.174E-05 | 1.206E-05 | 4.268E-04 |
| 2.00 | 21.12 | 2.968E-01 | 4.953E-02 | 17.00 | 2.84 | 45.72 | 5.29 | .02732 | 9.851E-06 | 1.011E-05 | 4.423E-04 |
| 1.99 | 22.87 | 3.039E-01 | 5.067E-02 | 17.41 | 2.90 | 45.52 | 5.41 | .02618 | 8.092E-06 | 8.295E-06 | 4.620E-04 |
| 1.97 | 24.95 | 3.120E-01 | 5.202E-02 | 17.93 | 2.98 | 45.26 | 5.55 | .02487 | 6.478E-06 | 6.632E-06 | 4.870E-04 |
| 1.96 | 27.45 | 3.243E-01 | 5.372E-02 | 18.58 | 3.08 | 44.92 | 5.74 | .02335 | 5.024E-06 | 5.136E-06 | 5.194E-04 |

RESULTS FOR TYPE II (O + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.66 | 3.66 | 4.264E-01 | 6.691E-02 | 24.43 | 3.83 | 45.52 | 7.14 | .01517 | 5.410E-05 | 5.488E-05 | 8.056E-04 |
| 3.61 | 3.71 | 4.295E-01 | 6.728E-02 | 24.61 | 3.85 | 45.46 | 7.18 | .01501 | 5.336E-05 | 5.412E-05 | 8.145E-04 |
| 3.56 | 3.76 | 4.325E-01 | 6.765E-02 | 24.78 | 3.88 | 45.40 | 7.22 | .01485 | 5.258E-05 | 5.332E-05 | 8.234E-04 |
| 3.52 | 3.81 | 4.356E-01 | 6.801E-02 | 24.96 | 3.90 | 45.33 | 7.26 | .01469 | 5.178E-05 | 5.250E-05 | 8.324E-04 |
| 3.47 | 3.87 | 4.387E-01 | 6.838E-02 | 25.14 | 3.92 | 45.27 | 7.30 | .01454 | 5.096E-05 | 5.166E-05 | 8.414E-04 |
| 3.43 | 3.92 | 4.418E-01 | 6.875E-02 | 25.32 | 3.94 | 45.20 | 7.34 | .01438 | 5.011E-05 | 5.080E-05 | 8.505E-04 |
| 3.39 | 3.98 | 4.450E-01 | 6.912E-02 | 25.50 | 3.96 | 45.13 | 7.38 | .01423 | 4.924E-05 | 4.991E-05 | 8.596E-04 |
| 3.35 | 4.04 | 4.482E-01 | 6.949E-02 | 25.68 | 3.98 | 45.06 | 7.42 | .01408 | 4.835E-05 | 4.900E-05 | 8.689E-04 |
| 3.31 | 4.10 | 4.514E-01 | 6.986E-02 | 25.86 | 4.00 | 44.99 | 7.46 | .01394 | 4.744E-05 | 4.807E-05 | 8.781E-04 |
| 3.27 | 4.16 | 4.546E-01 | 7.023E-02 | 26.05 | 4.02 | 44.92 | 7.50 | .01379 | 4.652E-05 | 4.712E-05 | 8.875E-04 |
| 3.23 | 4.22 | 4.579E-01 | 7.060E-02 | 26.24 | 4.05 | 44.85 | 7.54 | .01365 | 4.557E-05 | 4.616E-05 | 8.970E-04 |
| 3.19 | 4.29 | 4.612E-01 | 7.098E-02 | 26.43 | 4.07 | 44.77 | 7.58 | .01351 | 4.461E-05 | 4.518E-05 | 9.065E-04 |
| 3.16 | 4.36 | 4.646E-01 | 7.135E-02 | 26.62 | 4.09 | 44.70 | 7.62 | .01337 | 4.363E-05 | 4.418E-05 | 9.161E-04 |
| 3.12 | 4.43 | 4.680E-01 | 7.173E-02 | 26.82 | 4.11 | 44.62 | 7.66 | .01323 | 4.264E-05 | 4.317E-05 | 9.258E-04 |
| 3.08 | 4.50 | 4.715E-01 | 7.211E-02 | 27.01 | 4.13 | 44.55 | 7.70 | .01309 | 4.163E-05 | 4.215E-05 | 9.357E-04 |
| 3.05 | 4.57 | 4.750E-01 | 7.249E-02 | 27.21 | 4.15 | 44.47 | 7.74 | .01295 | 4.062E-05 | 4.112E-05 | 9.456E-04 |
| 3.02 | 4.65 | 4.785E-01 | 7.288E-02 | 27.42 | 4.18 | 44.38 | 7.78 | .01282 | 3.959E-05 | 4.007E-05 | 9.556E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.98 | 4.73 | 4.822E-01 | 7.326E-02 | 27.63 | 4.20 | 44.30 | 7.82 | .01269 | 3.855E-05 | 3.901E-05 | 9.650E-04 |
| 2.95 | 4.82 | 4.858E-01 | 7.365E-02 | 27.84 | 4.22 | 44.21 | 7.86 | .01255 | 3.750E-05 | 3.795E-05 | 9.761E-04 |
| 2.92 | 4.90 | 4.896E-01 | 7.404E-02 | 28.05 | 4.24 | 44.13 | 7.90 | .01242 | 3.645E-05 | 3.688E-05 | 9.865E-04 |
| 2.89 | 4.99 | 4.934E-01 | 7.444E-02 | 28.27 | 4.27 | 44.04 | 7.95 | .01229 | 3.539E-05 | 3.580E-05 | 9.971E-04 |
| 2.86 | 5.08 | 4.973E-01 | 7.484E-02 | 28.49 | 4.29 | 43.94 | 7.99 | .01216 | 3.433E-05 | 3.472E-05 | 1.008E-03 |
| 2.83 | 5.18 | 5.013E-01 | 7.524E-02 | 28.72 | 4.31 | 43.85 | 8.03 | .01203 | 3.326E-05 | 3.364E-05 | 1.019E-03 |
| 2.80 | 5.28 | 5.053E-01 | 7.565E-02 | 28.95 | 4.33 | 43.75 | 8.08 | .01191 | 3.218E-05 | 3.255E-05 | 1.030E-[illegible] |
| 2.77 | 5.38 | 5.095E-01 | 7.607E-02 | 29.19 | 4.36 | 43.65 | 8.12 | .01178 | 3.111E-05 | 3.146E-05 | 1.041E-[illegible] |
| 2.75 | 5.49 | 5.138E-01 | 7.648E-02 | 29.44 | 4.38 | 43.54 | 8.17 | .01165 | 3.004E-05 | 3.037E-05 | 1.053E-03 |
| 2.72 | 5.60 | 5.182E-01 | 7.691E-02 | 29.69 | 4.41 | 43.44 | 8.21 | .01152 | 2.896E-05 | 2.9[illegible]E-05 | 1.064E-03 |
| 2.69 | 5.72 | 5.227E-01 | 7.734E-02 | 29.95 | 4.43 | 43.32 | 8.26 | .01140 | 2.789E-05 | 2.819E-05 | 1.075E-03 |
| 2.67 | 5.84 | 5.274E-01 | 7.777E-02 | 30.22 | 4.46 | 43.21 | 8.30 | .01127 | 2.682E-05 | 2.710E-05 | 1.088E-03 |
| 2.64 | 5.97 | 5.322E-01 | 7.822E-02 | 30.49 | 4.48 | 43.08 | 8.35 | .01115 | 2.575E-05 | 2.602E-05 | 1.101E-03 |
| 2.61 | 6.10 | 5.372E-01 | 7.867E-02 | 30.78 | 4.51 | 42.96 | 8.40 | .01102 | 2.469E-05 | 2.495E-05 | 1.114E-03 |
| 2.59 | 6.24 | 5.423E-01 | 7.913E-02 | 31.07 | 4.53 | 42.83 | 8.45 | .01089 | 2.364E-05 | 2.388E-05 | 1.127E-03 |
| 2.57 | 6.38 | 5.477E-01 | 7.959E-02 | 31.38 | 4.56 | 42.69 | 8.50 | .01077 | 2.259E-05 | 2.282E-05 | 1.140E-03 |
| 2.54 | 6.54 | 5.532E-01 | 8.007E-02 | 31.70 | 4.59 | 42.54 | 8.55 | .01064 | 2.155E-05 | 2.177E-05 | 1.154E-03 |
| 2.52 | 6.70 | 5.590E-01 | 8.055E-02 | 32.03 | 4.62 | 42.39 | 8.60 | .01052 | 2.052E-05 | 2.073E-05 | 1.168E-03 |
| 2.50 | 6.86 | 5.651E-01 | 8.105E-02 | 32.38 | 4.64 | 42.23 | 8.65 | .01039 | 1.950E-05 | 1.970E-05 | 1.182E-03 |
| 2.47 | 7.04 | 5.714E-01 | 8.155E-02 | 32.74 | 4.67 | 42.06 | 8.71 | .01026 | 1.850E-05 | 1.868E-05 | 1.197E-03 |
| 2.45 | 7.22 | 5.781E-01 | 8.207E-02 | 33.12 | 4.70 | 41.88 | 8.76 | .01013 | 1.751E-05 | 1.767E-05 | 1.212E-03 |
| 2.43 | 7.42 | 5.851E-01 | 8.259E-02 | 33.52 | 4.73 | 41.68 | 8.82 | .01001 | 1.653E-05 | 1.669E-05 | 1.227E-03 |
| 2.41 | 7.62 | 5.925E-01 | 8.313E-02 | 33.95 | 4.76 | 41.48 | 8.87 | .00988 | 1.557E-05 | 1.571E-05 | 1.244E-03 |
| 2.39 | 7.84 | 6.003E-01 | 8.368E-02 | 34.40 | 4.79 | 41.26 | 8.93 | .00975 | 1.462E-05 | 1.476E-05 | 1.260E-03 |
| 2.37 | 8.07 | 6.086E-01 | 8.424E-02 | 34.87 | 4.83 | 41.02 | 8.99 | .00962 | 1.370E-05 | 1.382E-05 | 1.277E-03 |
| 2.35 | 8.32 | 6.175E-01 | 8.481E-02 | 35.38 | 4.86 | 40.77 | 9.05 | .00950 | 1.279E-05 | 1.291E-05 | 1.294E-03 |
| 2.33 | 8.58 | 6.270E-01 | 8.539E-02 | 35.92 | 4.89 | 40.49 | 9.12 | .00937 | 1.191E-05 | 1.201E-05 | 1.312E-03 |
| 2.31 | 8.85 | 6.372E-01 | 8.598E-02 | 36.51 | 4.93 | 40.19 | 9.18 | .00924 | 1.105E-05 | 1.114E-05 | 1.330E-03 |
| 2.29 | 9.15 | 6.482E-01 | 8.657E-02 | 37.14 | 4.96 | 39.86 | 9.24 | .00912 | 1.021E-05 | 1.030E-05 | 1.349E-03 |
| 2.27 | 9.47 | 6.601E-01 | 8.716E-02 | 37.82 | 4.99 | 39.50 | 9.31 | .00899 | 9.395E-06 | 9.475E-06 | 1.367E-03 |
| 2.25 | 9.80 | 6.730E-01 | 8.775E-02 | 38.56 | 5.03 | 39.10 | 9.37 | .00888 | 8.609E-06 | 8.681E-06 | 1.386E-03 |
| 2.23 | 10.17 | 6.872E-01 | 8.832E-02 | 39.37 | 5.06 | 38.65 | 9.43 | .00876 | 7.850E-06 | 7.915E-06 | 1.404E-03 |
| 2.21 | 10.56 | 7.028E-01 | 8.887E-02 | 40.27 | 5.09 | 38.15 | 9.49 | .00865 | 7.121E-06 | 7.179E-06 | 1.421E-03 |
| 2.20 | 10.98 | 7.200E-01 | 8.937E-02 | 41.25 | 5.12 | 37.59 | 9.54 | .00856 | 6.422E-06 | 6.474E-06 | 1.437E-03 |
| 2.18 | 11.44 | 7.392E-01 | 8.981E-02 | 42.35 | 5.15 | 36.95 | 9.59 | .00848 | 5.755E-06 | 5.801E-06 | 1.451E-03 |
| 2.16 | 11.93 | 7.608E-01 | 9.013E-02 | 43.59 | 5.16 | 36.22 | 9.62 | .00842 | 5.122E-06 | 5.162E-06 | 1.462E-03 |
| 2.14 | 12.48 | 7.852E-01 | 9.029E-02 | 44.99 | 5.17 | 35.36 | 9.64 | .00839 | 4.523E-06 | 4.558E-06 | 1.467E-03 |
| 2.13 | 13.07 | 8.131E-01 | 9.020E-02 | 46.59 | 5.17 | 34.36 | 9.63 | .00840 | 3.959E-06 | 3.991E-06 | 1.464E-03 |
| 2.11 | 13.72 | 8.455E-01 | 8.975E-02 | 48.44 | 5.14 | 33.17 | 9.58 | .00849 | 3.433E-06 | 3.460E-06 | 1.449E-03 |
| 2.10 | 14.45 | 8.836E-01 | 8.872E-02 | 50.62 | 5.08 | 31.72 | 9.47 | .00868 | 2.944E-06 | 2.968E-06 | 1.416E-03 |
| 2.08 | 15.25 | 9.292E-01 | 8.679E-02 | 53.24 | 4.97 | 29.92 | 9.27 | .00907 | 2.494E-06 | 2.515E-06 | 1.355E-03 |
| 2.06 | 16.15 | 9.853E-01 | 8.342E-02 | 56.46 | 4.78 | 27.63 | 8.91 | .00981 | 2.082E-06 | 2.102E-06 | 1.252E-03 |
| 2.05 | 17.16 | 1.057E+00 | 7.755E-02 | 60.57 | 4.44 | 24.57 | 8.28 | .01134 | [illegible].710E-06 | 1.729E-06 | 1.082E-03 |
| 2.03 | 18.30 | 1.156E+00 | 6.659E-02 | 66.22 | 3.83 | 20.16 | 7.14 | .01518 | 1.376E-06 | 1.396E-06 | 8.052E-04 |
| 2.02 | 19.61 | 1.316E+00 | 4.423E-02 | 75.40 | 2.53 | 12.61 | 4.72 | .03410 | 1.068E-06 | 1.104E-06 | 3.521E-04 |

PHASE MATCHING CUTS OFF AT SIGNAL= 2.004 AND IDLER= 21.115

PHASE MATCHING CUTS OFF AT SIGNAL= 1.999 AND IDLER= 22.875

PHASE MATCHING CUTS OFF AT SIGNAL= 1.975 AND IDLER= 24.955

PHASE MATCHING CUTS OFF AT SIGNAL= 1.961 AND IDLER= 27.450

RESULTS FOR TYPE II (E + O = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | PHO (RAD) | THETA (DEG) | PHO (DEG) | D-EFF (*10.E12) | R | H(R) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.66 | 3.66 | 4.264E-01 | 6.691E-02 | 24.43 | 3.83 | 45.52 | 7.14 | .01517 | 5.410E-05 | 5.480E-05 | 8.096E-04 |
| 3.61 | 3.71 | 4.234E-01 | 6.655E-02 | 24.26 | 3.81 | 45.58 | 7.10 | .01534 | 5.482E-05 | 5.562E-05 | 7.960E-04 |
| 3.56 | 3.76 | 4.204E-01 | 6.618E-02 | 24.09 | 3.79 | 45.65 | 7.07 | .01551 | 5.551E-05 | 5.633E-05 | 7.861E-04 |
| 3.52 | 3.81 | 4.174E-01 | 6.581E-02 | 23.92 | 3.77 | 45.71 | 7.03 | .01568 | 5.617E-05 | 5.701E-05 | 7.794E-04 |
| 3.47 | 3.87 | 4.145E-01 | 6.545E-02 | 23.75 | 3.75 | 45.77 | 6.99 | .01585 | 5.680E-05 | 5.766E-05 | 7.707E-04 |
| 3.43 | 3.92 | 4.115E-01 | 6.538E-02 | 23.58 | 3.73 | 45.83 | 6.95 | .01603 | 5.740E-05 | 5.827E-05 | 7.621E-04 |
| 3.39 | 3.98 | 4.086E-01 | 6.471E-02 | 23.41 | 3.71 | 45.88 | 6.91 | .01621 | 5.796E-05 | 5.885E-05 | 7.539E-04 |
| 3.35 | 4.04 | 4.056E-01 | 6.434E-02 | 23.24 | 3.69 | 45.94 | 6.87 | .01639 | 5.849E-05 | 5.940E-05 | 7.458E-04 |
| 3.31 | 4.10 | 4.027E-01 | 6.398E-02 | 23.07 | 3.67 | 46.00 | 6.83 | .01657 | 5.898E-05 | 5.991E-05 | [illegible] |
| 3.27 | 4.16 | 3.998E-01 | 6.361E-02 | 22.91 | 3.64 | 46.06 | 6.79 | .01676 | 5.944E-05 | 6.039E-05 | 7.281E-04 |
| 3.23 | 4.22 | 3.969E-01 | 6.324E-02 | 22.74 | 3.62 | 46.11 | 6.75 | .01696 | 5.986E-05 | 6.082E-05 | 7.197E-04 |
| 3.19 | 4.29 | 3.941E-01 | 6.287E-02 | 22.58 | 3.60 | 46.17 | 6.71 | .01715 | 6.023E-05 | 6.122E-05 | 7.113E-04 |
| 3.16 | 4.36 | 3.912E-01 | 6.250E-02 | 22.41 | 3.58 | 46.22 | 6.67 | .01735 | 6.057E-05 | 6.157E-05 | [illegible] |
| 3.12 | 4.43 | 3.883E-01 | 6.213E-02 | 22.25 | 3.56 | 46.28 | 6.63 | .01756 | 6.087E-05 | 6.189E-05 | 6.946E-04 |
| 3.08 | 4.50 | 3.855E-01 | 6.176E-02 | 22.09 | 3.54 | 46.33 | 6.59 | .01777 | 6.112E-05 | 6.216E-05 | 6.864E-04 |
| 3.05 | 4.57 | 3.826E-01 | 6.139E-02 | 21.92 | 3.52 | 46.38 | 6.55 | .01798 | 6.133E-05 | 6.238E-05 | 6.782E-04 |
| 3.02 | 4.65 | 3.798E-01 | 6.102E-02 | 21.76 | 3.50 | 46.44 | 6.51 | .01819 | 6.150E-05 | 6.256E-05 | 6.700E-04 |
| 2.98 | 4.73 | 3.770E-01 | 6.065E-02 | 21.60 | 3.47 | 46.49 | 6.47 | .01841 | 6.162E-05 | 6.270E-05 | 6.618E-04 |
| 2.95 | 4.82 | 3.742E-01 | 6.028E-02 | 21.44 | 3.45 | 46.54 | 6.43 | .01864 | 5.169E-05 | 6.278E-05 | 6.537E-04 |
| 2.92 | 4.90 | 3.714E-01 | 5.990E-02 | 21.28 | 3.43 | 46.59 | 6.40 | .01887 | 6.171E-05 | 6.282E-05 | 6.457E-04 |
| 2.89 | 4.99 | 3.686E-01 | 5.953E-02 | 21.12 | 3.41 | 46.64 | 6.36 | .01910 | 6.168E-05 | 6.281E-05 | 6.377E-04 |
| 2.86 | 5.08 | 3.658E-01 | 5.916E-02 | 20.96 | 3.39 | 46.69 | 6.32 | .01934 | 6.161E-05 | 6.274E-05 | 6.297E-04 |
| 2.83 | 5.18 | 3.630E-01 | 5.878E-02 | 20.80 | 3.37 | 46.74 | 6.28 | .01958 | 6.148E-05 | 6.262E-05 | 6.218E-04 |
| 2.80 | 5.28 | 3.603E-01 | 5.841E-02 | 20.64 | 3.35 | 46.79 | 6.24 | .01982 | 6.129E-05 | 6.245E-05 | 6.139E-04 |
| 2.77 | 5.38 | 3.575E-01 | 5.804E-02 | 20.48 | 3.33 | 46.84 | 6.20 | .02008 | 6.106E-05 | 6.223E-05 | 6.061E-04 |
| 2.75 | 5.49 | 3.548E-01 | 5.766E-02 | 20.33 | 3.30 | 46.89 | 6.16 | .02033 | 6.076E-05 | 6.194E-05 | 5.983E-04 |
| 2.72 | 5.60 | 3.521E-01 | 5.729E-02 | 20.17 | 3.28 | 46.93 | 6.12 | .02059 | 6.042E-05 | 6.160E-05 | 5.906E-04 |
| 2.69 | 5.72 | 3.494E-01 | 5.692E-02 | 20.02 | 3.26 | 46.98 | 6.08 | .02086 | 6.001E-05 | 6.121E-05 | 5.829E-04 |
| 2.67 | 5.84 | 3.467E-01 | 5.654E-02 | 19.86 | 3.24 | 47.03 | 6.04 | .02113 | 5.955E-05 | 6.075E-05 | [illegible] |
| 2.64 | 5.97 | 3.440E-01 | 5.617E-02 | 19.71 | 3.22 | 47.07 | 6.00 | .02140 | 5.902E-05 | 6.023E-05 | [illegible] |
| 2.61 | 6.10 | 3.413E-01 | 5.580E-02 | 19.56 | 3.20 | 47.12 | 5.96 | .02168 | 5.844E-05 | 5.965E-05 | [illegible] |
| 2.59 | 6.24 | 3.387E-01 | 5.543E-02 | 19.40 | 3.18 | 47.16 | 5.92 | .02197 | 5.779E-05 | 5.901E-05 | 5.529E-04 |
| 2.57 | 6.38 | 3.360E-01 | 5.506E-02 | 19.25 | 3.15 | 47.20 | 5.88 | .02225 | 5.708E-05 | 5.830E-05 | 5.456E-04 |
| 2.54 | 6.54 | 3.334E-01 | 5.470E-02 | 19.10 | 3.13 | 47.25 | 5.84 | .02255 | 5.631E-05 | 5.753E-05 | 5.384E-04 |
| 2.52 | 6.70 | 3.308E-01 | 5.434E-02 | 18.96 | 3.11 | 47.29 | 5.80 | .02284 | 5.540E-05 | 5.669E-05 | 5.313E-04 |
| 2.50 | 6.86 | 3.283E-01 | 5.398E-02 | 18.81 | 3.09 | 47.33 | 5.76 | .02314 | 5.450E-05 | 5.579E-05 | 5.242E-04 |
| 2.47 | 7.04 | 3.258E-01 | 5.362E-02 | 18.67 | 3.07 | 47.37 | 5.72 | .02344 | 5.361E-05 | 5.482E-05 | 5.173E-04 |
| 2.45 | 7.22 | 3.233E-01 | 5.327E-02 | 18.52 | 3.05 | 47.41 | 5.69 | .02375 | 5.250E-05 | 5.370E-05 | [illegible] |
| 2.43 | 7.42 | 3.208E-01 | 5.292E-02 | 18.38 | 3.03 | 47.45 | 5.65 | .02406 | 5.140E-05 | 5.267E-05 | 5.039E-04 |
| 2.41 | 7.62 | 3.184E-01 | 5.257E-02 | 18.25 | 3.01 | 47.49 | 5.61 | .02436 | 3.032E-05 | 5.150E-05 | 4.973E-04 |
| 2.39 | 7.84 | 3.161E-01 | 5.224E-02 | 18.11 | 2.99 | 47.52 | 5.58 | .02467 | 4.909E-05 | 5.029E-05 | 4.910E-04 |
| 2.37 | 8.07 | 3.138E-01 | 5.191E-02 | 17.98 | 2.97 | 47.56 | 5.54 | .02498 | 4.779E-05 | 4.894E-05 | 4.848E-04 |
| 2.35 | 8.32 | 3.115E-01 | 5.158E-02 | 17.85 | 2.96 | 47.59 | 5.51 | .02529 | 4.643E-05 | 4.756E-05 | 4.708E-04 |
| 2.33 | 8.58 | 3.094E-01 | 5.127E-02 | 17.73 | 2.94 | 47.63 | 5.47 | .02553 | 4.500E-05 | 4.611E-05 | 4.720E-04 |
| 2.31 | 8.85 | 3.073E-01 | 5.097E-02 | 17.61 | 2.92 | 47.66 | 5.44 | .02569 | 4.351E-05 | 4.459E-05 | 4.674E-04 |
| 2.29 | 9.15 | 3.053E-01 | 5.068E-02 | 17.49 | 2.90 | 47.69 | 5.41 | .02610 | 4.196E-05 | 4.301E-05 | 4.621E-04 |
| 2.27 | 9.47 | 3.033E-01 | 5.040E-02 | 17.38 | 2.89 | 47.72 | 5.38 | .02646 | 4.034E-05 | 4.136E-05 | 4.571E-04 |
| 2.25 | 9.80 | 3.015E-01 | 5.014E-02 | 17.28 | 2.87 | 47.74 | 5.35 | .02673 | 3.866E-05 | 3.965E-05 | 4.523E-04 |
| 2.23 | 10.17 | 2.999E-01 | 4.990E-02 | 17.18 | 2.86 | 47.77 | 5.33 | .02698 | 3.693E-05 | 3.700E-05 | 4.480E-04 |
| 2.21 | 10.56 | 2.983E-01 | 4.967E-02 | 17.09 | 2.85 | 47.79 | 5.30 | .02722 | 3.514E-05 | 3.606E-05 | 4.440E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.20 | 10.98 | 2.959E-01 | 4.948E-02 | 17.01 | 2.83 | 47.81 | 5.29 | .02743 | 3.330E-05 | 3.418E-05 | 4.409E-04 |
| 2.18 | 11.44 | 2.957E-01 | 4.931E-02 | 16.95 | 2.83 | 47.83 | 5.26 | .02761 | 3.151E-05 | 3.229E-05 | 4.379E-04 |
| 2.16 | 11.93 | 2.948E-01 | 4.917E-02 | 16.89 | 2.82 | 47.84 | 5.25 | .02776 | 2.949E-05 | 3.027E-05 | 4.350E-04 |
| 2.14 | 12.48 | 2.940E-01 | 4.907E-02 | 16.85 | 2.81 | 47.85 | 5.24 | .02788 | 2.753E-05 | 2.827E-05 | 4.332E-04 |
| 2.13 | 13.07 | 2.936E-01 | 4.901E-02 | 16.82 | 2.81 | 47.86 | 5.23 | .02794 | 2.554E-05 | 2.623E-05 | 4.322E-04 |
| 2.11 | 13.72 | 2.934E-01 | 4.900E-02 | 16.81 | 2.81 | 47.85 | 5.23 | .02795 | 2.354E-05 | 2.417E-05 | 4.320E-04 |
| 2.10 | 14.45 | 2.937E-01 | 4.905E-02 | 16.83 | 2.81 | 47.86 | 5.24 | .02798 | 2.153E-05 | 2.210E-05 | 4.329E-04 |
| 2.08 | 15.25 | 2.944E-01 | 4.916E-02 | 16.87 | 2.82 | 47.85 | 5.25 | .02777 | 1.952E-05 | 2.004E-05 | 4.349E-04 |
| 2.06 | 16.15 | 2.956E-01 | 4.936E-02 | 16.94 | 2.83 | 47.83 | 5.27 | .02755 | 1.753E-05 | 1.799E-05 | 4.384E-04 |
| 2.05 | 17.16 | 2.975E-01 | 4.965E-02 | 17.04 | 2.84 | 47.80 | 5.30 | .02724 | 1.556E-05 | 1.597E-05 | 4.436E-04 |
| 2.03 | 18.30 | 3.000E-01 | 5.005E-02 | 17.19 | 2.87 | 47.77 | 5.34 | .02682 | 1.364E-05 | 1.399E-05 | 4.508E-04 |
| 2.02 | 19.61 | 3.035E-01 | 5.059E-02 | 17.39 | 2.90 | 47.71 | 5.40 | .02626 | 1.179E-05 | 1.208E-05 | 4.606E-04 |
| 2.00 | 21.12 | 3.082E-01 | 5.130E-02 | 17.65 | 2.94 | 47.64 | 5.48 | .02556 | 1.001E-05 | 1.025E-05 | 4.739E-04 |
| 1.99 | 22.87 | 3.142E-01 | 5.221E-02 | 18.00 | 2.99 | 47.55 | 5.57 | .02470 | 8.329E-06 | 8.526E-06 | 4.914E-04 |
| 1.97 | 24.95 | 3.220E-01 | 5.338E-02 | 18.45 | 3.06 | 47.43 | 5.70 | .02365 | 6.765E-06 | 6.910E-06 | 5.120E-04 |
| 1.96 | 27.45 | 3.321E-01 | 5.499E-02 | 19.03 | 3.14 | 47.27 | 5.86 | .02240 | 5.335E-06 | 5.450E-06 | 5.419E-04 |

PROGRAM NONLIN--COLINEARLY PHASE MATCHED OPO

CINNABAR

PHASE MATCHING FOR POSITIVE BIREFRINGENT CRYSTAL

PUMP WAVELENGTH(MICRONS)= 2.100

NONLINEAR COEFFICIENTS(X10 E12 M/V)= 50.000 0.000 -0.000 -0.000 -0.000

CUTOFF WAVELENGTH= 30.000

RESULTS FOR TYPE I (E + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | R | N(R) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.20 | 4.20 | 2.759E-01 | 4.573E-02 | 15.81 | 2.62 | 46.29 | 4.55 | .03660 | 8.967E-05 | 9.289E-05 | 3.760E-04 |
| 4.14 | 4.26 | 2.759E-01 | 4.574E-02 | 15.81 | 2.62 | 46.29 | 4.55 | .03659 | 8.961E-05 | 9.279E-05 | 3.761E-04 |
| 4.09 | 4.32 | 2.759E-01 | 4.574E-02 | 15.81 | 2.62 | 46.29 | 4.55 | .03658 | 8.950E-05 | 9.267E-05 | 3.762E-04 |
| 4.04 | 4.38 | 2.758E-01 | 4.575E-02 | 15.80 | 2.62 | 46.29 | 4.55 | .03657 | 8.933E-05 | 9.250E-05 | 3.762E-04 |
| 3.99 | 4.44 | 2.758E-01 | 4.575E-02 | 15.80 | 2.62 | 46.29 | 4.55 | .03657 | 8.912E-05 | 9.228E-05 | 3.762E-04 |
| 3.94 | 4.50 | 2.757E-01 | 4.574E-02 | 15.80 | 2.62 | 46.29 | 4.55 | .03658 | 8.885E-05 | 9.200E-05 | 3.762E-04 |
| 3.89 | 4.57 | 2.756E-01 | 4.574E-02 | 15.79 | 2.62 | 46.30 | 4.55 | .03659 | 8.854E-05 | 9.168E-05 | 3.761E-04 |
| 3.84 | 4.63 | 2.755E-01 | 4.573E-02 | 15.79 | 2.62 | 46.30 | 4.55 | .03660 | 8.817E-05 | 9.130E-05 | 3.759E-04 |
| 3.80 | 4.70 | 2.754E-01 | 4.572E-02 | 15.78 | 2.62 | 46.30 | 4.55 | .03662 | 8.775E-05 | 9.086E-05 | 3.758E-04 |
| 3.75 | 4.77 | 2.752E-01 | 4.571E-02 | 15.77 | 2.62 | 46.31 | 4.55 | .03664 | 8.727E-05 | 9.037E-05 | 3.755E-04 |
| 3.71 | 4.85 | 2.751E-01 | 4.569E-02 | 15.76 | 2.62 | 46.31 | 4.55 | .03666 | 8.675E-05 | 8.983E-05 | 3.753E-04 |
| 3.66 | 4.92 | 2.749E-01 | 4.567E-02 | 15.75 | 2.62 | 46.32 | 4.55 | .03669 | 8.618E-05 | 8.924E-05 | 3.750E-04 |
| 3.62 | 5.00 | 2.747E-01 | 4.565E-02 | 15.74 | 2.62 | 46.32 | 4.54 | .03672 | 8.555E-05 | 8.860E-05 | 3.746E-04 |
| 3.58 | 5.08 | 2.745E-01 | 4.563E-02 | 15.73 | 2.61 | 46.33 | 4.54 | .03676 | 8.487E-05 | 8.790E-05 | 3.743E-04 |
| 3.54 | 5.16 | 2.743E-01 | 4.560E-02 | 15.72 | 2.61 | 46.33 | 4.54 | .03680 | 8.414E-05 | 8.714E-05 | 3.739E-04 |
| 3.50 | 5.25 | 2.741E-01 | 4.557E-02 | 15.70 | 2.61 | 46.34 | 4.54 | .03684 | 8.336E-05 | 8.634E-05 | 3.734E-04 |
| 3.46 | 5.34 | 2.739E-01 | 4.554E-02 | 15.69 | 2.61 | 46.34 | 4.53 | .03689 | 8.253E-05 | 8.548E-05 | 3.729E-04 |
| 3.42 | 5.43 | 2.736E-01 | 4.551E-02 | 15.68 | 2.61 | 46.35 | 4.53 | .03693 | 8.165E-05 | 8.457E-05 | 3.724E-04 |
| 3.39 | 5.53 | 2.733E-01 | 4.549E-02 | 15.66 | 2.61 | 46.36 | 4.53 | .03698 | 8.072E-05 | 8.361E-05 | 3.719E-04 |
| 3.35 | 5.62 | 2.731E-01 | 4.545E-02 | 15.65 | 2.60 | 46.36 | 4.52 | .03704 | 7.973E-05 | 8.260E-05 | 3.713E-04 |
| 3.32 | 5.73 | 2.728E-01 | 4.541E-02 | 15.63 | 2.60 | 46.37 | 4.52 | .03709 | 7.870E-05 | 8.153E-05 | 3.708E-04 |
| 3.28 | 5.83 | 2.725E-01 | 4.538E-02 | 15.61 | 2.60 | 46.38 | 4.52 | .03715 | 7.761E-05 | 8.041E-05 | 3.702E-04 |
| 3.25 | 5.94 | 2.722E-01 | 4.534E-02 | 15.60 | 2.60 | 46.39 | 4.51 | .03721 | 7.648E-05 | 7.924E-05 | 3.696E-04 |
| 3.21 | 6.06 | 2.719E-01 | 4.530E-02 | 15.58 | 2.60 | 46.39 | 4.51 | .03727 | 7.529E-05 | 7.802E-05 | 3.689E-04 |
| 3.18 | 6.18 | 2.716E-01 | 4.526E-02 | 15.56 | 2.59 | 46.40 | 4.51 | .03733 | 7.406E-05 | 7.674E-05 | 3.683E-04 |
| 3.15 | 6.30 | 2.713E-01 | 4.522E-02 | 15.55 | 2.59 | 46.41 | 4.50 | .03740 | 7.278E-05 | 7.542E-05 | 3.677E-04 |
| 3.12 | 6.43 | 2.710E-01 | 4.519E-02 | 15.53 | 2.59 | 46.42 | 4.50 | .03746 | 7.144E-05 | 7.404E-05 | 3.670E-04 |
| 3.09 | 6.56 | 2.707E-01 | 4.514E-02 | 15.51 | 2.59 | 46.42 | 4.49 | .03752 | 7.006E-05 | 7.261E-05 | 3.664E-04 |
| 3.06 | 6.70 | 2.704E-01 | 4.510E-02 | 15.49 | 2.58 | 46.43 | 4.49 | .03758 | 6.863E-05 | 7.114E-05 | 3.657E-04 |
| 3.03 | 6.85 | 2.701E-01 | 4.507E-02 | 15.48 | 2.58 | 46.44 | 4.49 | .03764 | 6.715E-05 | 6.961E-05 | 3.651E-04 |
| 3.00 | 7.00 | 2.698E-01 | 4.503E-02 | 15.46 | 2.58 | 46.45 | 4.48 | .03770 | 6.563E-05 | 6.803E-05 | 3.645E-04 |
| 2.97 | 7.16 | 2.696E-01 | 4.500E-02 | 15.44 | 2.58 | 46.45 | 4.48 | .03776 | 6.406E-05 | 6.641E-05 | 3.640E-04 |
| 2.94 | 7.33 | 2.693E-01 | 4.496E-02 | 15.43 | 2.58 | 46.45 | 4.48 | .03781 | 6.245E-05 | 6.474E-05 | 3.635E-04 |
| 2.92 | 7.50 | 2.691E-01 | 4.493E-02 | 15.42 | 2.57 | 46.47 | 4.47 | .03786 | 6.079E-05 | 6.302E-05 | 3.630E-04 |
| 2.89 | 7.68 | 2.689E-01 | 4.491E-02 | 15.40 | 2.57 | 46.47 | 4.47 | .03790 | 5.908E-05 | 6.126E-05 | 3.626E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.86 | 7.87 | 2.687E-01 | 4.499E-02 | 15.39 | 2.57 | 46.48 | 4.47 | .03794 | 5.734E-05 | 5.945E-05 | 3.622E-04 |
| 2.84 | 8.08 | 2.685E-01 | 4.497E-02 | 15.38 | 2.57 | 46.49 | 4.47 | .03797 | 5.555E-05 | 5.760E-05 | 3.619E-04 |
| 2.81 | 8.29 | 2.684E-01 | 4.496E-02 | 15.38 | 2.57 | 46.48 | 4.47 | .03798 | 5.373E-05 | 5.571E-05 | 3.618E-04 |
| 2.79 | 8.51 | 2.683E-01 | 4.495E-02 | 15.37 | 2.57 | 46.49 | 4.47 | .03799 | 5.187E-05 | 5.378E-05 | 3.617E-04 |
| 2.76 | 8.75 | 2.683E-01 | 4.495E-02 | 15.37 | 2.57 | 46.49 | 4.47 | .03799 | 4.997E-05 | 5.181E-05 | 3.617E-04 |
| 2.74 | 9.00 | 2.683E-01 | 4.497E-02 | 15.37 | 2.57 | 46.49 | 4.47 | .03797 | 4.804E-05 | 4.981E-05 | 3.619E-04 |
| 2.72 | 9.25 | 2.684E-01 | 4.499E-02 | 15.38 | 2.57 | 46.48 | 4.47 | .03793 | 4.608E-05 | 4.778E-05 | 3.623E-04 |
| 2.69 | 9.55 | 2.686E-01 | 4.492E-02 | 15.39 | 2.57 | 46.48 | 4.47 | .03788 | 4.409E-05 | 4.571E-05 | 3.628E-04 |
| 2.67 | 9.84 | 2.688E-01 | 4.497E-02 | 15.40 | 2.58 | 45.47 | 4.48 | .03781 | 4.208E-05 | 4.362E-05 | 3.639E-04 |
| 2.65 | 10.16 | 2.691E-01 | 4.503E-02 | 15.42 | 2.58 | 46.46 | 4.48 | .03771 | 4.004E-05 | 4.151E-05 | 3.645E-04 |
| 2.63 | 10.50 | 2.696E-01 | 4.510E-02 | 15.45 | 2.58 | 46.45 | 4.49 | .03759 | 3.799E-05 | 3.938E-05 | 3.65[illegible]E-04 |
| 2.60 | 10.86 | 2.702E-01 | 4.520E-02 | 15.48 | 2.59 | 46.44 | 4.50 | .03743 | 3.593E-05 | 3.723E-05 | 3.6[illegible]3E-04 |
| 2.58 | 11.25 | 2.709E-01 | 4.532E-02 | 15.52 | 2.60 | 46.42 | 4.51 | .03725 | 3.385E-05 | 3.507E-05 | 3.692E-04 |
| 2.56 | 11.67 | 2.717E-01 | 4.546E-02 | 15.57 | 2.60 | 46.40 | 4.53 | .03702 | 3.177E-05 | 3.291E-05 | 3.719E-04 |
| 2.54 | 12.12 | 2.728E-01 | 4.563E-02 | 15.63 | 2.61 | 46.37 | 4.54 | .03676 | 2.969E-05 | 3.075E-05 | 3.743E-04 |
| 2.52 | 12.60 | 2.740E-01 | 4.593E-02 | 15.70 | 2.63 | 46.34 | 4.56 | .03645 | 2.762E-05 | 2.860E-05 | 3.776E-04 |
| 2.50 | 13.12 | 2.755E-01 | 4.605E-02 | 15.79 | 2.64 | 46.30 | 4.59 | .03609 | 2.557E-05 | 2.646E-05 | 3.815E-04 |
| 2.48 | 13.70 | 2.773E-01 | 4.634E-02 | 15.89 | 2.66 | 46.25 | 4.61 | .03567 | 2.353E-05 | 2.435E-05 | 3.861E-04 |
| 2.46 | 14.32 | 2.7[illegible]3E-01 | 4.667E-02 | 16.01 | 2.67 | 46.20 | 4.65 | .03519 | 2.153E-05 | 2.226E-05 | 3.915E-04 |
| 2.44 | 15.00 | 2.8[illegible]8E-01 | 4.705E-02 | 16.14 | 2.70 | 46.13 | 4.68 | .03465 | 1.956E-05 | 2.021E-05 | 3.979E-04 |
| 2.42 | 15.75 | 2.846E-01 | 4.749E-02 | 16.31 | 2.72 | 46.06 | 4.73 | .03402 | 1.763E-05 | 1.822E-05 | 4.054E-04 |
| 2.40 | 16.58 | 2.879E-01 | 4.800E-02 | 16.50 | 2.75 | 45.97 | 4.78 | .03332 | 1.577E-05 | 1.627E-05 | 4.142E-04 |
| 2.39 | 17.50 | 2.918E-01 | 4.860E-02 | 16.72 | 2.78 | 45.86 | 4.84 | .03253 | 1.396E-05 | 1.440E-05 | 4.246E-04 |
| 2.37 | 18.53 | 2.963E-01 | 4.929E-02 | 16.99 | 2.82 | 45.74 | 4.91 | .03165 | 1.223E-05 | 1.261E-05 | 4.368E-04 |
| 2.35 | 19.69 | 3.017E-01 | 5.010E-02 | 17.28 | 2.87 | 45.59 | 4.99 | .03066 | 1.059E-05 | 1.090E-05 | 4.513E-04 |
| 2.33 | 21.00 | 3.079E-01 | 5.105E-02 | 17.64 | 2.93 | 45.41 | 5.09 | .02956 | 9.033E-06 | 9.290E-06 | 4.686E-04 |
| 2.32 | 22.50 | 3.154E-01 | 5.217E-02 | 18.07 | 2.99 | 45.19 | 5.19 | .02834 | 7.584E-06 | 7.791E-06 | 4.893E-04 |
| 2.30 | 24.23 | 3.243E-01 | 5.349E-02 | 18.58 | 3.06 | 44.92 | 5.32 | .02788 | 6.246E-06 | 6.489E-06 | 5.144E-04 |
| 2.28 | 26.25 | 3.350E-01 | 5.506E-02 | 19.19 | 3.15 | 44.60 | 5.48 | .02552 | 5.029E-06 | 5.153E-06 | 5.451E-04 |
| 2.27 | 28.64 | 3.481E-01 | 5.695E-02 | 19.95 | 3.26 | 44.18 | 5.67 | .02388 | 3.939E-06 | 4.038E-06 | 5.832E-04 |

RESULTS FOR TYPE II (O + E = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.20 | 4.20 | 3.935E-01 | 6.254E-02 | 22.55 | 3.58 | 46.18 | 6.23 | .01989 | 4.849E-05 | 4.941E-05 | 7.032E-04 |
| 4.14 | 4.26 | 3.963E-01 | 6.290E-02 | 22.71 | 3.60 | 46.12 | 6.26 | .01966 | 4.783E-05 | 4.872E-05 | 7.112E-04 |
| 4.09 | 4.32 | 3.991E-01 | 6.325E-02 | 22.87 | 3.62 | 46.07 | 6.30 | .01945 | 4.713E-05 | 4.801E-05 | 7.193E-04 |
| 4.04 | 4.38 | 4.020E-01 | 6.362E-02 | 23.03 | 3.64 | 46.01 | 6.33 | .01923 | 4.641E-05 | 4.726E-05 | 7.276E-04 |
| 3.99 | 4.44 | 4.049E-01 | 6.398E-02 | 23.20 | 3.67 | 45.96 | 6.37 | .01902 | 4.567E-05 | 4.649E-05 | 7.359E-04 |
| 3.94 | 4.50 | 4.079E-01 | 6.435E-02 | 23.37 | 3.69 | 45.90 | 6.41 | .01880 | 4.49[illegible]E-05 | 4.570E-05 | 7.444E-04 |
| 3.89 | 4.57 | 4.109E-01 | 6.472E-02 | 23.54 | 3.71 | 45.84 | 6.44 | .01859 | 4.410E-05 | 4.488E-05 | 7.530E-04 |
| 3.84 | 4.63 | 4.139E-01 | 6.509E-02 | 23.71 | 3.73 | 45.78 | 6.48 | .01838 | 4.329E-05 | 4.405E-05 | 7.617E-04 |
| 3.80 | 4.70 | 4.170E-01 | 6.547E-02 | 23.89 | 3.75 | 45.72 | 6.52 | .01817 | 4.245E-05 | 4.319E-05 | 7.706E-04 |
| 3.75 | 4.77 | 4.201E-01 | 6.585E-02 | 24.07 | 3.77 | 45.65 | 6.56 | .01797 | 4.160E-05 | 4.231E-05 | 7.796E-04 |
| 3.71 | 4.85 | 4.233E-01 | 6.624E-02 | 24.25 | 3.80 | 45.59 | 6.59 | .01776 | 4.072E-05 | 4.141E-05 | 7.888E-04 |
| 3.66 | 4.92 | 4.266E-01 | 6.663E-02 | 24.44 | 3.82 | 45.52 | 6.63 | .01756 | 3.983E-05 | 4.050E-05 | 7.981E-04 |
| 3.62 | 5.00 | 4.299E-01 | 6.702E-02 | 24.63 | 3.84 | 45.45 | 6.67 | .01736 | 3.893E-05 | 3.957E-05 | 8.076E-04 |
| 3.58 | 5.08 | 4.333E-01 | 6.742E-02 | 24.82 | 3.86 | 45.38 | 6.71 | .01715 | 3.801E-05 | 3.863E-05 | 8.173E-04 |
| 3.54 | 5.16 | 4.367E-01 | 6.783E-02 | 25.02 | 3.89 | 45.31 | 6.75 | .01695 | 3.707E-05 | 3.767E-05 | 8.271E-04 |
| 3.50 | 5.25 | 4.402E-01 | 6.824E-02 | 25.22 | 3.91 | 45.23 | 6.79 | .01675 | 3.612E-05 | 3.670E-05 | 8.372E-04 |
| 3.46 | 5.34 | 4.438E-01 | 6.865E-02 | 25.43 | 3.93 | 45.16 | 6.83 | .01655 | 3.516E-05 | 3.572E-05 | 8.474E-04 |
| 3.42 | 5.43 | 4.475E-01 | 6.919E-02 | 25.64 | 3.96 | 45.08 | 6.88 | .01635 | 3.420E-05 | 3.473E-05 | 8.579E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.39 | 5.53 | 4.513E-01 | 6.951E-02 | 25.85 | 3.98 | 44.99 | 6.92 | .01616 | 3.322E-05 | 3.373E-05 | 8.686E-04 |
| 3.35 | 5.62 | 4.552E-01 | 6.994E-02 | 26.08 | 4.01 | 44.91 | 6.96 | .01596 | 3.223E-05 | 3.272E-05 | 8.799E-04 |
| 3.32 | 5.73 | 4.591E-01 | 7.039E-02 | 26.31 | 4.03 | 44.82 | 7.01 | .01576 | 3.124E-05 | 3.171E-05 | 8.907E-04 |
| 3.28 | 5.83 | 4.632E-01 | 7.084E-02 | 26.54 | 4.06 | 44.73 | 7.05 | .01556 | 3.025E-05 | 3.069E-05 | 9.021E-04 |
| 3.25 | 5.94 | 4.676E-01 | 7.130E-02 | 26.78 | 4.08 | 44.64 | 7.10 | .01537 | 2.925E-05 | 2.967E-05 | 9.139E-04 |
| 3.21 | 6.06 | 4.718E-01 | 7.176E-02 | 27.03 | 4.11 | 44.54 | 7.14 | .01517 | 2.824E-05 | 2.865E-05 | 9.259E-04 |
| 3.18 | 6.18 | 4.763E-01 | 7.224E-02 | 27.29 | 4.14 | 44.44 | 7.19 | .01497 | 2.724E-05 | 2.763E-05 | 5.383E-04 |
| 3.15 | 6.30 | 4.809E-01 | 7.273E-02 | 27.55 | 4.17 | 44.33 | 7.24 | .01479 | 2.623E-05 | 2.660E-05 | 9.510E-04 |
| 3.12 | 6.43 | 4.857E-01 | 7.323E-02 | 27.83 | 4.20 | 44.22 | 7.29 | .01458 | 2.523E-05 | 2.558E-05 | 9.640E-04 |
| 3.09 | 6.56 | 4.906E-01 | 7.374E-02 | 28.11 | 4.22 | 44.10 | 7.34 | .01438 | 2.423E-05 | 2.456E-05 | 9.779E-04 |
| 3.06 | 6.70 | 4.958E-01 | 7.426E-02 | 28.41 | 4.25 | 43.98 | 7.39 | .01418 | 2.323E-05 | 2.355E-05 | 9.913E-04 |
| 3.03 | 6.85 | 5.011E-01 | 7.479E-02 | 28.71 | 4.29 | 43.85 | 7.45 | .01398 | 2.224E-05 | 2.254E-05 | 1.006E-03 |
| 3.00 | 7.00 | 5.067E-01 | 7.533E-02 | 29.03 | 4.32 | 43.72 | 7.50 | .01378 | 2.126E-05 | 2.153E-05 | 1.023E-03 |
| 2.97 | 7.16 | 5.125E-01 | 7.589E-02 | 29.37 | 4.35 | 43.58 | 7.56 | .01358 | 2.028E-05 | 2.054E-05 | 1.036E-03 |
| 2.94 | 7.33 | 5.186E-01 | 7.647E-02 | 29.72 | 4.38 | 43.43 | 7.61 | .01338 | 1.931E-05 | 1.955E-05 | 1.051E-03 |
| 2.92 | 7.50 | 5.250E-01 | 7.706E-02 | 30.08 | 4.42 | 43.27 | 7.67 | .01318 | 1.835E-05 | 1.858E-05 | 1.068E-03 |
| 2.89 | 7.68 | 5.317E-01 | 7.766E-02 | 30.46 | 4.45 | 43.10 | 7.73 | .01298 | 1.740E-05 | 1.762E-05 | 1.084E-03 |
| 2.86 | 7.87 | 5.388E-01 | 7.828E-02 | 30.87 | 4.49 | 42.92 | 7.79 | .01278 | 1.647E-05 | 1.667E-05 | 1.102E-03 |
| 2.84 | 8.08 | 5.462E-01 | 7.892E-02 | 31.29 | 4.52 | 42.73 | 7.86 | .01257 | 1.555E-05 | 1.573E-05 | 1.120E-03 |
| 2.81 | 8.29 | 5.540E-01 | 7.959E-02 | 31.74 | 4.56 | 42.52 | 7.92 | .01237 | 1.464E-05 | 1.481E-05 | 1.138E-03 |
| 2.79 | 8.51 | 5.624E-01 | 8.025E-02 | 32.22 | 4.60 | 42.30 | 7.99 | .01217 | 1.375E-05 | 1.391E-05 | 1.158E-03 |
| 2.76 | 8.75 | 5.712E-01 | 8.094E-02 | 32.73 | 4.64 | 42.06 | 8.06 | .01196 | 1.288E-05 | 1.303E-05 | 1.178E-03 |
| 2.74 | 9.00 | 5.807E-01 | 8.165E-02 | 33.27 | 4.68 | 41.81 | 8.13 | .01176 | 1.203E-05 | 1.217E-05 | 1.198E-03 |
| 2.72 | 9.26 | 5.907E-01 | 8.237E-02 | 33.85 | 4.72 | 41.53 | 8.20 | .01155 | 1.120E-05 | 1.132E-05 | 1.220E-03 |
| 2.69 | 9.55 | 6.016E-01 | 8.311E-02 | 34.47 | 4.76 | 41.22 | 8.27 | .01135 | 1.039E-05 | 1.051E-05 | 1.242E-03 |
| 2.67 | 9.84 | 6.132E-01 | 8.386E-02 | 35.13 | 4.80 | 40.89 | 8.35 | .01115 | 9.609E-06 | 9.718E-06 | 1.264E-03 |
| 2.65 | 10.16 | 6.258E-01 | 8.462E-02 | 35.85 | 4.85 | 40.53 | 8.42 | .01095 | 8.849E-06 | 8.941E-06 | 1.287E-03 |
| 2.63 | 10.50 | 6.394E-01 | 8.538E-02 | 36.63 | 4.89 | 40.12 | 8.50 | .01076 | 8.115E-06 | 8.198E-06 | 1.311E-03 |
| 2.60 | 10.86 | 6.542E-01 | 8.614E-02 | 37.49 | 4.94 | 39.68 | 8.57 | .01058 | 7.409E-06 | 7.483E-06 | 1.334E-03 |
| 2.58 | 11.25 | 6.705E-01 | 8.687E-02 | 38.42 | 4.98 | 39.18 | 8.65 | .01040 | 6.730E-06 | 6.797E-06 | 1.357E-03 |
| 2.56 | 11.67 | 6.884E-01 | 8.758E-02 | 39.44 | 5.02 | 38.61 | 8.72 | .01023 | 6.082E-06 | 6.141E-06 | 1.379E-03 |
| 2.54 | 12.12 | 7.081E-01 | 8.823E-02 | 40.57 | 5.06 | 37.98 | 8.78 | .01008 | 5.464E-06 | 5.516E-06 | 1.399E-03 |
| 2.52 | 12.60 | 7.302E-01 | 8.879E-02 | 41.86 | 5.09 | 37.25 | 8.84 | .00996 | 4.878E-06 | 4.924E-06 | 1.417E-03 |
| 2.50 | 13.12 | 7.549E-01 | 8.923E-02 | 43.25 | 5.11 | 36.42 | 8.88 | .00987 | 4.325E-06 | 4.366E-06 | 1.431E-03 |
| 2.48 | 13.70 | 7.828E-01 | 8.941E-02 | 44.85 | 5.12 | 35.45 | 8.90 | .00982 | 3.806E-06 | 3.841E-06 | 1.437E-03 |
| 2.46 | 14.32 | 8.148E-01 | 8.929E-02 | 46.68 | 5.12 | 34.30 | 8.89 | .00985 | 3.321E-06 | 3.352E-06 | 1.433E-03 |
| 2.44 | 15.00 | 8.518E-01 | 8.870E-02 | 48.81 | 5.08 | 32.93 | 8.83 | .00998 | 2.870E-06 | 2.897E-06 | 1.414E-03 |
| 2.42 | 15.75 | 8.953E-01 | 8.737E-02 | 51.30 | 5.01 | 31.26 | 8.70 | .01029 | 2.455E-06 | 2.479E-06 | 1.372E-03 |
| 2.40 | 16.58 | 9.477E-01 | 8.438E-02 | 54.30 | 4.86 | 29.18 | 8.45 | .01089 | 2.076E-06 | 2.097E-06 | 1.299E-03 |
| 2.39 | 17.50 | 1.012E+00 | 8.050E-02 | 58.01 | 4.61 | 26.49 | 8.01 | .01209 | 1.731E-06 | 1.751E-06 | 1.165E-03 |
| 2.37 | 18.53 | 1.097E+00 | 7.279E-02 | 62.87 | 4.17 | 22.33 | 7.25 | .01475 | 1.421E-06 | 1.440E-06 | 9.529E-04 |
| 2.35 | 19.69 | 1.217E+00 | 5.822E-02 | 69.73 | 3.34 | 17.32 | 5.80 | .02288 | 1.141E-06 | 1.169E-06 | 6.893E-04 |
| 2.33 | 21.00 | 1.474E+00 | 1.728E-02 | 84.43 | .99 | 4.85 | 1.72 | .21255 | 7.409E-07 | 9.249E-07 | 5.369E-05 |

PHASE MATCHING CUTS OFF AT SIGNAL= 2.316 AND IDLER= 22.508

PHASE MATCHING CUTS OFF AT SIGNAL= 2.299 AND IDLER= 24.231

PHASE MATCHING CUTS OFF AT SIGNAL= 2.283 AND IDLER= 26.250

PHASE MATCHING CUTS OFF AT SIGNAL= 2.266 AND IDLER= 28.636

RESULTS FOR TYPE II (E + O = O) PHASE MATCHING ARE

| SIGNAL | IDLER | THETA (RAD) | RHO (RAD) | THETA (DEG) | RHO (DEG) | D-EFF (*10.E12) | B | H(B) | GAIN/WATT (1CM) | GAIN/WATT (MAX) | AREA (SQ CM) |
|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.20 | 4.20 | 3.935E-01 | 6.254E-02 | 22.55 | 3.58 | 46.19 | 6.23 | .01989 | 4.849E-05 | 4.941E-05 | 7.032E-04 |
| 4.14 | 4.26 | 3.908E-01 | 6.219E-02 | 22.39 | 3.56 | 46.23 | 6.19 | .02011 | 4.913E-05 | 5.007E-05 | 6.952E-04 |
| 4.09 | 4.32 | 3.880E-01 | 6.184E-02 | 22.23 | 3.54 | 46.28 | 6.16 | .02033 | 4.973E-05 | 5.070E-05 | 6.874E-04 |
| 4.04 | 4.38 | 3.853E-01 | 6.149E-02 | 22.[illegible] | 3.52 | 46.33 | 6.12 | .02056 | 5.031E-05 | 5.130E-05 | 6.797E-04 |
| 3.99 | 4.44 | 3.827E-01 | 6.114E-02 | 21.93 | 3.50 | 46.39 | 6.09 | .02079 | 5.085E-05 | 5.186E-05 | 6.721E-04 |
| 3.94 | 4.50 | 3.800E-01 | 6.080E-02 | 21.77 | 3.48 | 46.43 | 6.05 | .02102 | 5.136E-05 | 5.239E-05 | 6.645E-04 |
| 3.89 | 4.57 | 3.774E-01 | 6.045E-02 | 21.62 | 3.46 | 46.48 | 6.02 | .02125 | 5.184E-05 | 5.289E-05 | 6.571E-04 |
| 3.84 | 4.63 | 3.748E-01 | 6.012E-02 | 21.49 | 3.44 | 46.53 | 5.98 | .02149 | 5.227E-05 | 5.335E-05 | 6.497E-04 |
| 3.80 | 4.70 | 3.723E-01 | 5.978E-02 | 21.33 | 3.43 | 46.57 | 5.95 | .02173 | 5.268E-05 | 5.377E-05 | 6.424E-04 |
| 3.75 | 4.77 | 3.698E-01 | 5.944E-02 | 21.19 | 3.41 | [illegible] | 5.92 | .02197 | 5.304E-05 | 5.415E-05 | 6.353E-04 |
| 3.71 | 4.85 | 3.673E-01 | 5.911E-02 | 21.04 | 3.39 | 46.67 | 5.89 | .02221 | 5.336E-05 | 5.450E-05 | 6.282E-04 |
| 3.66 | 4.92 | 3.648E-01 | 5.878E-02 | 20.90 | 3.37 | 46.71 | 5.85 | .02246 | 5.365E-05 | 5.480E-05 | 6.211E-04 |
| 3.62 | 5.00 | 3.623E-01 | 5.845E-02 | 20.76 | 3.35 | 46.75 | 5.82 | .02270 | 5.389E-05 | 5.506E-05 | 6.142E-04 |
| 3.58 | 5.08 | 3.599E-01 | 5.812E-02 | 20.62 | 3.33 | 46.80 | 5.79 | .02296 | 5.409E-05 | 5.527E-05 | 6.073E-04 |
| 3.54 | 5.16 | 3.575E-01 | 5.780E-02 | 20.48 | 3.31 | 46.86 | 5.75 | .02321 | 5.424E-05 | 5.545E-05 | 6.005E-04 |
| 3.50 | 5.25 | 3.551E-01 | 5.747E-02 | 20.35 | 3.29 | 46.88 | 5.72 | .02347 | 5.435E-05 | 5.557E-05 | 5.938E-04 |
| 3.46 | 5.34 | 3.527E-01 | 5.715E-02 | 20.21 | 3.27 | 46.92 | 5.69 | .02372 | 5.442E-05 | 5.565E-05 | 5.872E-04 |
| 3.42 | 5.43 | 3.504E-01 | 5.683E-02 | 20.08 | 3.26 | 46.96 | 5.66 | .02399 | 5.444E-05 | 5.569E-05 | 5.807E-04 |
| 3.39 | 5.53 | 3.481E-01 | 5.652E-02 | 19.94 | 3.24 | 47.00 | 5.63 | .02425 | 5.441E-05 | 5.567E-05 | 5.742E-04 |
| 3.35 | 5.62 | 3.458E-01 | 5.620E-02 | 19.81 | 3.22 | 47.04 | 5.59 | .02452 | 5.433E-05 | 5.560E-05 | 5.678E-04 |
| 3.32 | 5.73 | 3.435E-01 | 5.589E-02 | 19.68 | 3.20 | 47.08 | 5.56 | .02478 | 5.420E-05 | 5.549E-05 | 5.616E-04 |
| 3.28 | 5.83 | 3.413E-01 | 5.558E-02 | 19.56 | 3.19 | 47.12 | 5.53 | .02505 | 5.402E-05 | 5.532E-05 | 5.554E-04 |
| 3.25 | 5.94 | 3.391E-01 | 5.527E-02 | 19.43 | 3.17 | 47.15 | 5.50 | .02533 | 5.379E-05 | 5.509E-05 | 5.492E-04 |
| 3.21 | 6.06 | 3.369E-01 | 5.497E-02 | 19.30 | 3.15 | 47.19 | 5.47 | .02560 | 5.350E-05 | 5.482E-05 | 5.432E-04 |
| 3.18 | 6.18 | 3.348E-01 | 5.467E-02 | 19.18 | 3.13 | 47.22 | 5.44 | .02588 | 5.317E-05 | 5.449E-05 | 5.373E-04 |
| 3.15 | 6.30 | 3.326E-01 | 5.437E-02 | 19.06 | 3.12 | 47.26 | 5.41 | .02615 | 5.278E-05 | 5.410E-05 | 5.315E-04 |
| 3.12 | 6.43 | 3.305E-01 | 5.408E-02 | 18.94 | 3.10 | 47.29 | 5.38 | .02643 | 5.233E-05 | 5.366E-05 | 5.257E-04 |
| 3.09 | 6.56 | 3.285E-01 | 5.379E-02 | 18.82 | 3.08 | 47.33 | 5.35 | .02671 | 5.193E-05 | 5.316E-05 | 5.201E-04 |
| 3.06 | 6.70 | 3.264E-01 | 5.350E-02 | 18.70 | 3.07 | 47.36 | 5.33 | .02699 | 5.127E-05 | 5.260E-05 | 5.146E-04 |
| 3.03 | 6.85 | 3.244E-01 | 5.322E-02 | 18.59 | 3.05 | 47.39 | 5.30 | .02727 | 5.066E-05 | 5.198E-05 | 5.092E-04 |
| 3.00 | 7.00 | 3.225E-01 | 5.294E-02 | 18.48 | 3.03 | 47.42 | 5.27 | .02754 | 4.998E-05 | 5.131E-05 | 5.039E-04 |
| 2.97 | 7.16 | 3.206E-01 | 5.267E-02 | 18.37 | 3.02 | 47.45 | 5.24 | .02782 | 4.925E-05 | 5.057E-05 | 4.988E-04 |
| 2.94 | 7.33 | 3.187E-01 | 5.241E-02 | 18.26 | 3.00 | 47.48 | 5.22 | .02810 | 4.847E-05 | 4.979E-05 | 4.937E-04 |
| 2.92 | 7.50 | 3.169E-01 | 5.215E-02 | 18.15 | 2.99 | 47.51 | 5.19 | .02837 | 4.762E-05 | 4.892E-05 | 4.889E-04 |
| 2.89 | 7.68 | 3.151E-01 | 5.189E-02 | 18.05 | 2.97 | 47.54 | 5.17 | .02864 | 4.672E-05 | 4.801E-05 | 4.841E-04 |
| 2.86 | 7.87 | 3.134E-01 | 5.165E-02 | 17.95 | 2.96 | 47.56 | 5.14 | .02891 | 4.576E-05 | 4.703E-05 | 4.796E-04 |
| 2.84 | 8.08 | 3.117E-01 | 5.141E-02 | 17.86 | 2.95 | 47.59 | 5.12 | .02917 | 4.474E-05 | 4.600E-05 | 4.752E-04 |
| 2.81 | 8.29 | 3.101E-01 | 5.118E-02 | 17.77 | 2.93 | 47.61 | 5.10 | .02942 | 4.366E-05 | 4.490E-05 | 4.710E-04 |
| 2.79 | 8.51 | 3.086E-01 | 5.096E-02 | 17.68 | 2.92 | 47.64 | 5.07 | .02966 | 4.253E-05 | 4.375E-05 | 4.670E-04 |
| 2.76 | 8.75 | 3.072E-01 | 5.076E-02 | 17.60 | 2.91 | 47.66 | 5.05 | .02990 | 4.135E-05 | 4.254E-05 | 4.632E-04 |
| 2.74 | 9.00 | 3.058E-01 | 5.056E-02 | 17.52 | 2.90 | 47.68 | 5.03 | .03013 | 4.010E-05 | 4.127E-05 | 4.596E-04 |
| 2.72 | 9.26 | 3.045E-01 | 5.038E-02 | 17.45 | 2.89 | 47.70 | 5.02 | .03034 | 3.881E-05 | 3.994E-05 | 4.563E-04 |
| 2.69 | 9.55 | 3.033E-01 | 5.021E-02 | 17.38 | 2.88 | 47.72 | 5.00 | .03054 | 3.746E-05 | 3.857E-05 | 4.532E-04 |
| 2.67 | 9.84 | 3.022E-01 | 5.006E-02 | 17.32 | 2.87 | 47.73 | 4.98 | .03072 | 3.607E-05 | 3.714E-05 | 4.505E-04 |
| 2.65 | 10.16 | 3.013E-01 | 4.992E-02 | 17.26 | 2.86 | 47.75 | 4.97 | .03088 | 3.463E-05 | 3.566E-05 | 4.480E-04 |
| 2.63 | 10.50 | 3.005E-01 | 4.981E-02 | 17.22 | 2.85 | 47.76 | 4.96 | .03102 | 3.314E-05 | 3.413E-05 | 4.460E-04 |
| 2.60 | 10.85 | 2.998E-01 | 4.971E-02 | 17.18 | 2.85 | 47.77 | 4.95 | .03113 | 3.162E-05 | 3.257E-05 | 4.443E-04 |
| 2.58 | 11.25 | 2.993E-01 | 4.964E-02 | 17.15 | 2.84 | 47.78 | 4.94 | .03122 | 3.005E-05 | 3.096E-05 | 4.431E-04 |
| 2.56 | 11.67 | 2.989E-01 | 4.960E-02 | 17.13 | 2.84 | 47.78 | 4.94 | .03127 | 2.846E-05 | 2.932E-05 | 4.423E-04 |
| 2.54 | 12.12 | 2.988E-01 | 4.959E-02 | 17.12 | 2.84 | 47.78 | 4.94 | .03128 | 2.683E-05 | 2.764E-05 | 4.421E-04 |
| 2.52 | 12.60 | 2.989E-01 | 4.961E-02 | 17.13 | 2.84 | 47.78 | 4.94 | .03126 | 2.519E-05 | 2.599E-05 | 4.429E-04 |
| 2.50 | 13.12 | 2.992E-01 | 4.967E-02 | 17.15 | 2.85 | 47.78 | 4.94 | .03118 | 2.353E-05 | 2.423E-05 | 4.438E-04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.48 | 13.70 | 2.999F-01 | 4.978E-02 | 17.18 | 2.85 | 47.77 | 4.96 | .03186 | 2.105E-05 | 2.251E-05 | 4.494E-04 |
| 2.46 | 14.32 | 3.008F-01 | 4.993E-02 | 17.24 | 2.86 | 47.75 | 4.97 | .03087 | 2.018E-05 | 2.078E-05 | 4.442E-04 |
| 2.44 | 15.00 | 3.022F-01 | 5.014E-02 | 17.31 | 2.87 | 47.73 | 4.99 | .03067 | 1.851E-05 | 1.985E-05 | 4.519E-04 |
| 2.42 | 15.75 | 3.039F-01 | 5.041E-02 | 17.41 | 2.89 | 47.71 | 5.02 | .03031 | 1.685E-05 | 1.735E-05 | 4.568E-04 |
| 2.40 | 16.56 | 3.062E-01 | 5.075E-02 | 17.54 | 2.91 | 47.68 | 5.05 | .02991 | 1.522E-05 | 1.566E-05 | 4.631E-04 |
| 2.39 | 17.50 | 3.090E-01 | 5.118E-02 | 17.78 | 2.93 | 47.63 | 5.09 | .02942 | 1.362E-05 | 1.401E-05 | 4.709E-04 |
| 2.37 | 18.53 | 3.124F-01 | 5.170E-02 | 17.98 | 2.96 | 47.58 | 5.15 | .02884 | 1.206E-05 | 1.248E-05 | 4.806E-04 |
| 2.35 | 19.69 | 3.167F-01 | 5.234E-02 | 18.14 | 3.00 | 47.51 | 5.21 | .02816 | 1.056E-05 | 1.089E-05 | 4.920E-04 |
| 2.33 | 21.04 | 3.219F-01 | 5.312E-02 | 18.44 | 3.04 | 47.43 | 5.29 | .02737 | 9.126E-06 | 9.306E-06 | 5.078E-04 |
| 2.32 | 22.58 | 3.282F-01 | 5.405E-02 | 18.88 | 3.10 | 47.33 | 5.38 | .02645 | 7.705E-06 | 7.902E-06 | 5.253E-04 |
| 2.30 | 24.23 | 3.359F-01 | 5.518E-02 | 19.25 | 3.16 | 47.21 | 5.49 | .02541 | 6.498E-06 | 6.646E-06 | 5.479E-04 |
| 2.28 | 26.25 | 3.454F-01 | 5.655E-02 | 19.79 | 3.24 | 47.05 | 5.63 | .02422 | 5.313E-06 | 5.436E-06 | 5.750E-04 |
| 2.27 | 28.64 | 3.571F-01 | 5.823E-02 | 20.46 | 3.34 | 46.85 | 5.88 | .02287 | 4.242E-06 | 4.334E-06 | 6.099E-04 |



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